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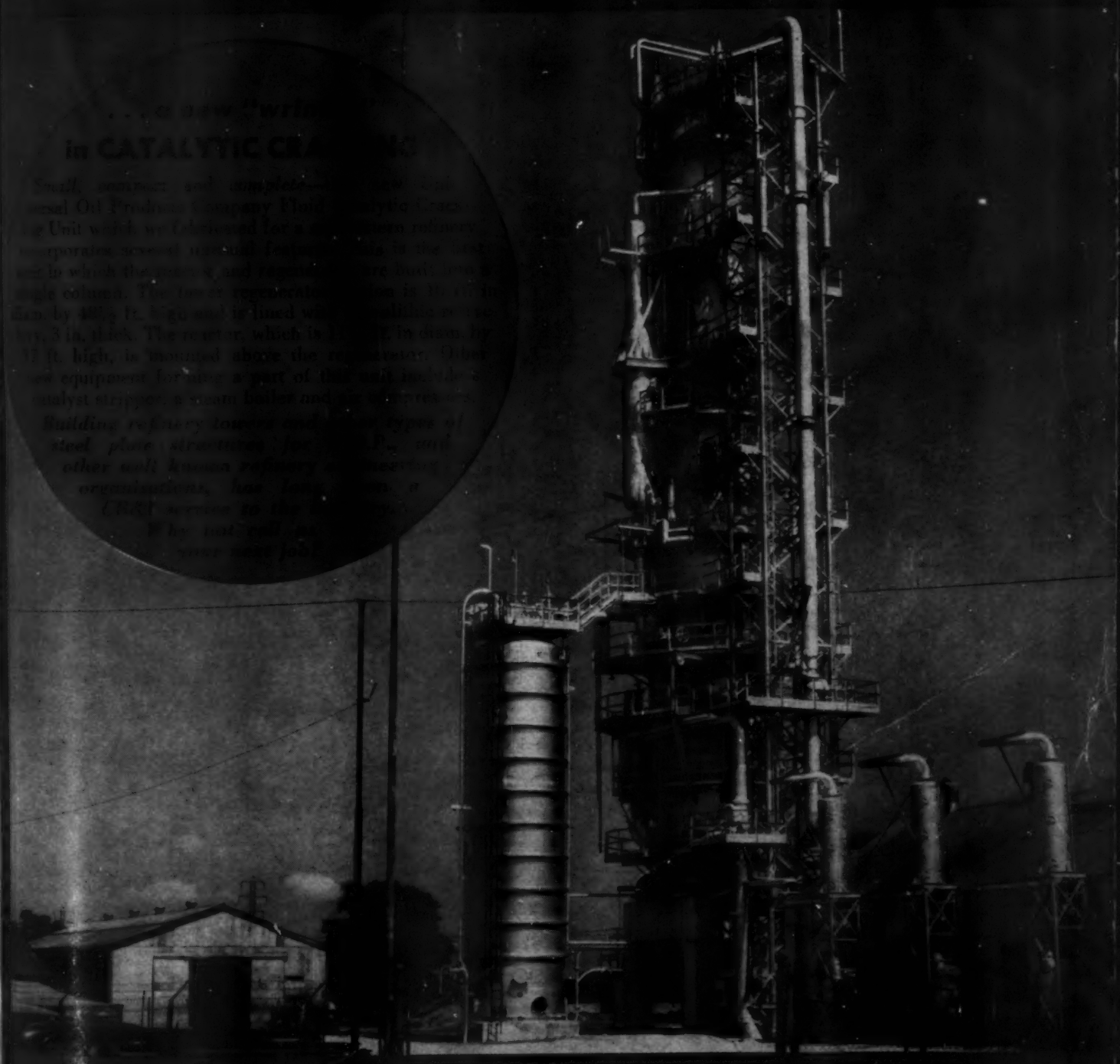

...Design
...Fabrication
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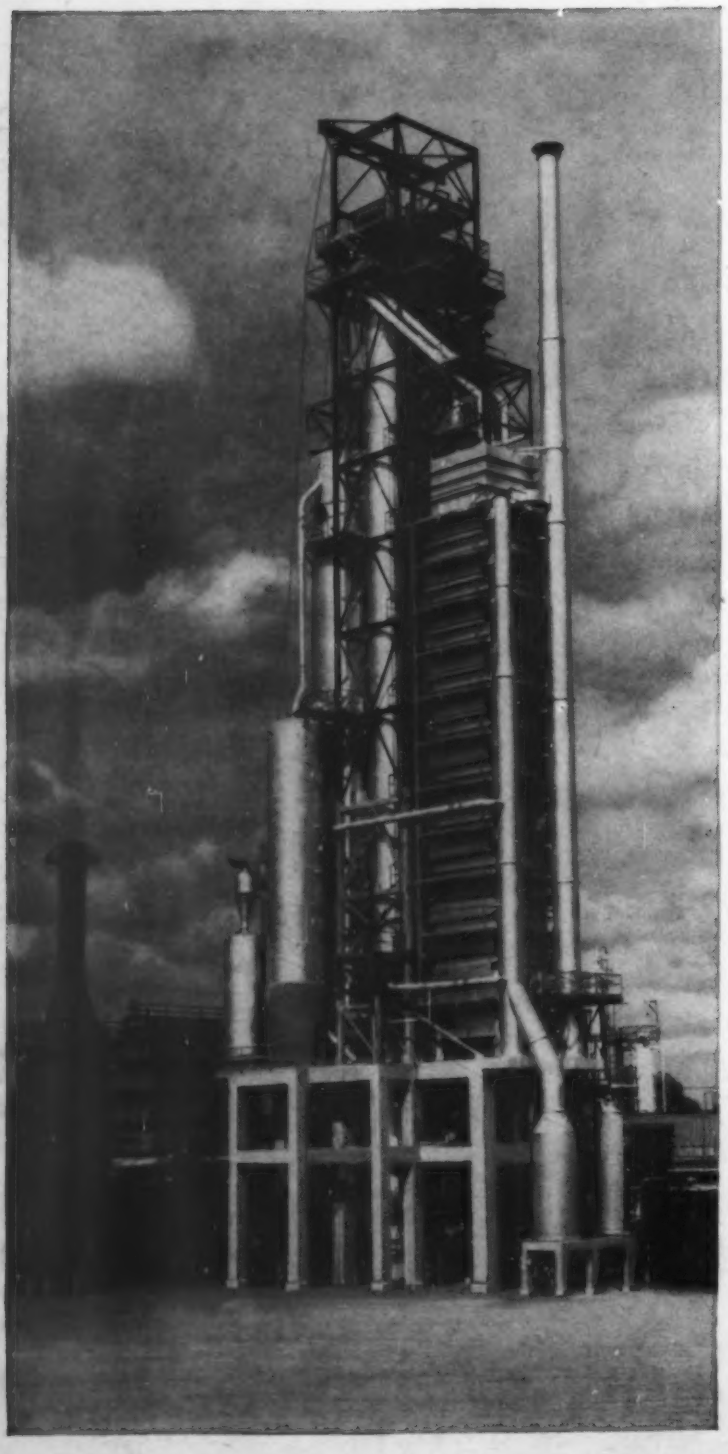
Lion's new TCC unit goes on stream!



On September 16, the sixty-seventh Houdry-licensed cat cracker—and the thirty-eighth TCC—went on stream in the refinery of Lion Oil Company at El Dorado, Arkansas. This unit is of 4,500 bbl. fresh feed capacity, with 900 bbls. additional capacity for recycling.

This new Lion unit will process high-sulfur crude (1.8% in the reactor charge). Corrosion protection is provided by lining the reactor, fractionating tower and all vessels with alloyed steel.

In actual operation, this new TCC unit is running 20% over design capacity, enabling Lion to maintain the high octane quality of its motor gasoline output at considerably reduced costs. And, with built-in recycling, the refiner will be able to vary his product distribution at will, according to seasonal demands.

These are advantages inherent in TCC which have made it the catalytic cracking process outstandingly favored by refineries of relatively moderate size. Details will be furnished gladly to interested refiners.

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THE LOOK BOX

MUCH has been said lately concerning the efforts of refiners to supply the current heavy demands for petroleum products, and from available figures on runs to stills and production records it has been evident that the whole industry is performing an amazing feat of high-capacity plant operation.

A Sample of Excellent Work

A specific instance of the manner in which this program is being carried forward is to be found in a brief news item from *The Stanocolan*, which is published at Baton Rouge by the Louisiana Division of the Standard Oil Company of New Jersey:

"A step-up in production without an increase in operating facilities is the job laid out for the Baton Rouge refinery.

"Refinery pipe stills have been operating at rates up to 18,000 barrels a day, as compared to normal operating capacity of 15,000 barrels. Catalytic cracking units have been stepped up from their normal 22,000 barrel-a-day capacity to 25,000 barrels daily. By using cracking coils to run additional crude oils, the refinery's crude run has been increased from the 176,000 barrels-a-day average of 1946 to a present operating rate of 210,000 barrels daily.

"On October 22, the isomerization unit, out since 1945, was put back into operation to provide butane necessary for the operation of the refinery's three alkylation units. These will soon be going 'full blast' to meet increased requirements of high octane aviation gasoline.

"This remarkable increase in production is a combined achievement of technical, operating, and maintenance people.

"Minor bottlenecks have been eliminated and units have been put and kept in tip-top condition.

"Over at No. 7 pipe still, greatest producer of its kind at the refinery, with a daily capacity of 58,000 barrels, overflow feed systems and an end-fire still have been installed so that this unit feeds from the same tank all the time, and no time is lost in shifting lines to other tanks.

"Operators at the phenol plant have increased the daily output of their unit by some 200 barrels per day. Better operation and better maintenance is the answer here."

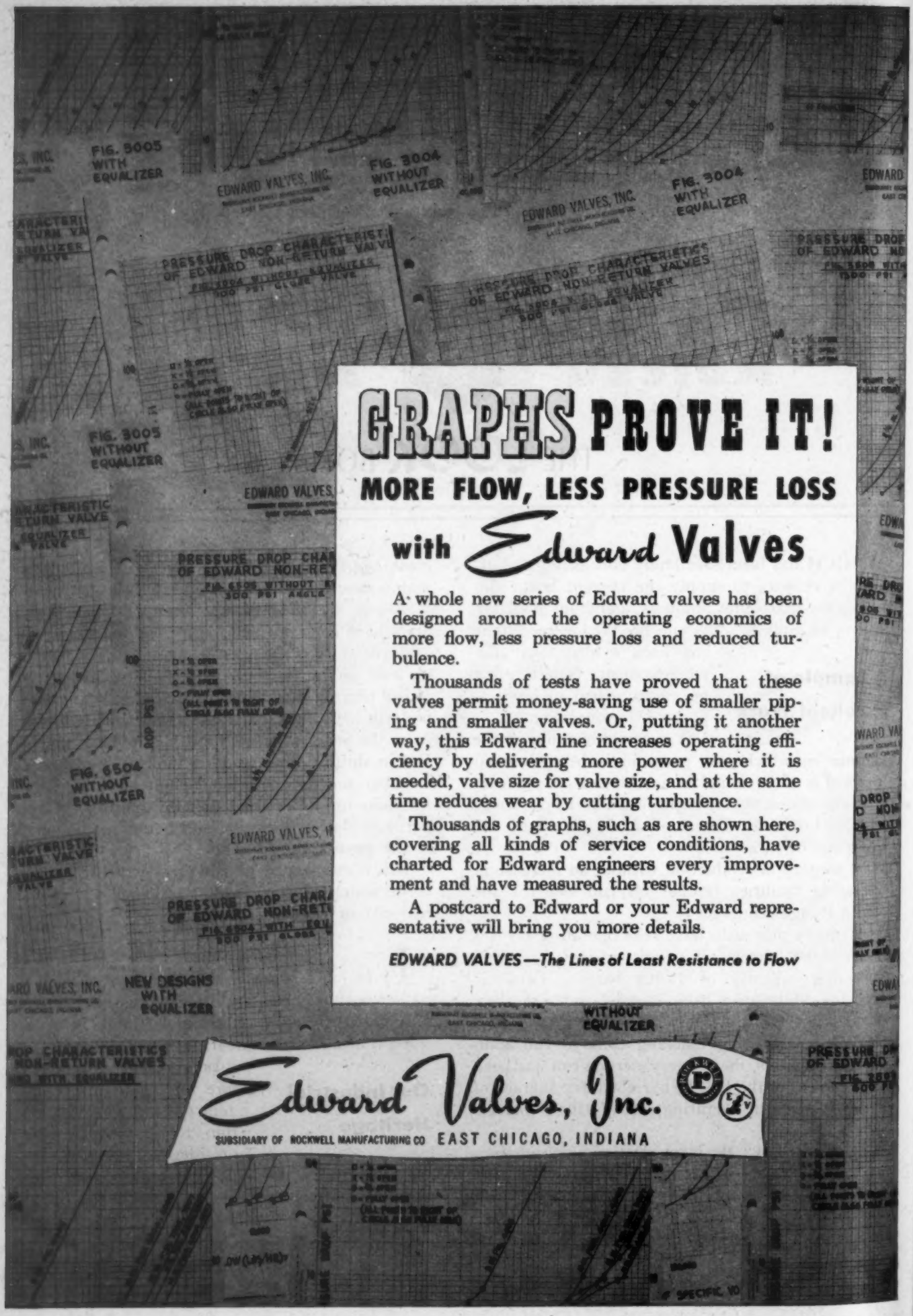
This is excellent work and praiseworthy achievement, which is being closely paralleled in the great majority of our country's refineries.

"IT IS more urgent today than ever that all of us be constantly mindful of our industrial heritage and constantly point out in understandable terms what it means to the American people."

Our Industrial Heritage

In a recent address before the Texas Mid-Continent Oil and Gas Association, Robert G. Dunlop, president of Sun Oil Company, expanded the statement above into an explanation of factors currently important in our industry.

Attacks are being made upon the oil industry which unless rebuffed will destroy its characteristic progressive and competitive nature. Such attacks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EDWARD VALVES, INC.
FIG. 3004 WITH EQUALIZER
PRESSURE DROP CHARACTERISTICS OF EDWARD NON-RETURN VALVES
FIG. 3004 WITHOUT EQUALIZER
300 PSI GLOBE VALVE
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are being made upon the entire business structure of the country with increased subtlety and tempo. They come from men who are collectivists at heart and whose purpose is to bring our economic system under the paralyzing hand of government dictation.

Some advocates of such a course are sincere in their expressed belief that thereby business can be made to operate with greater benefit to the mass of people, but they are men without apparent knowledge or understanding of the way competitive enterprise functions.

Many of those leading the current crusade against business are insincere in their protestations of good motives. Either they are tainted with the collectivist philosophy of the all-powerful State, which seemingly is sweeping so devastatingly over the world, or they are opportunists who know better, but care not what means they use to accomplish their selfish ends. They all propagate distortions and untruths which unless corrected will eventually destroy the American competitive structure and with its freedom of choice, our most precious possession.

In essence their current pleas follow a common line, namely, that there is taking place increased economic concentration that threatens the survival of the small operator and is harmful to the public welfare. Little in the way of factual evidence is offered to sustain the charge. Those who make it are content to paint a picture of a David and Goliath relationship between small and large units—a false portrait of economic class warfare.

Recently such contentions have been directed against the oil industry. They have consisted of great sound and fury, but little substance. The purpose is to split our industry into warring, contentious fractions in order that schemes for government control and restriction may be imposed upon it.

Only the unthinking will be fooled by such hollow efforts. Since the dissolution of the Standard Oil Trust in 1911 there has been a decrease of economic concentration in the oil industry. This is amply evidenced by the spirited competition of the 34,000 companies comprising our industry. In no place is that competition sharper than among the larger companies.

Behind these contentions of economic concentration in oil has been the implication that the door of opportunity in the oil field has been closed. This is untrue; opportunity is as great today as it ever has been for the man or group of men with initiative, courage, know-how and reasonable resources to take advantage of it.

There can be no dominant company or group in the production end of our business, for instance when the largest operator produces less than 8 percent of the country's total production; when the 20 largest companies—all keenly competitive—produce only a little over half of that total, and when there are engaged in the business of producing oil and gas more than 13,000 independent operators.

There is no foundation in the oil industry for this false issue of "big" versus "little" business. The larger companies cannot and do not stand alone. There is an interdependence of large and small units that is essential to the efficient functioning of the industry as a whole. Most of the large companies purchase substantial portions of the crude they run to stills from the small operators. Smaller operators have made most of the discoveries of oil in this country. The large—the integrated company—has been the small producers' best customer.

Providing The Margin

THE nation's users of petroleum products, including gasoline, are being asked to conserve as much as possible.

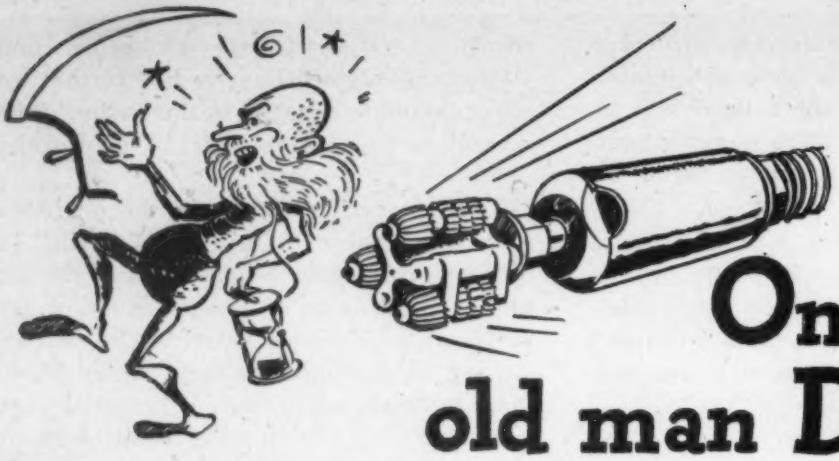
In an address delivered last month at the first conference of District No. 3, National Association of Purchasing Agents, A. J. McIntosh, economist of Socony-Vacuum Oil Company, Inc., asserted that "a gallon of gasoline saved makes a gallon of fuel oil available to someone."

Pointing out that no one was able to foresee the tremendous growth in postwar demands for all kinds of petroleum products, the Socony-Vacuum executive blamed the war for limiting normal expansion of facilities in the petroleum industry and asserted that new ones planned or under construction take "time, steel and vast sums of money."

McIntosh pointed out that the petroleum industry met unprecedented demands last summer for gasoline—deliveries amounted to two percent more than the estimates of how much would be needed—but this was accomplished by making more gasoline out of each barrel of crude oil than would otherwise have been indicated. He continued:

"The country needs cooperation of all users of petroleum products to conserve any and all kinds. A gallon of gasoline saved makes a gallon of fuel oil available to someone. Home owners saved from 15 to 25 percent of fuel oil for heating during the war as compared with prewar. Prudence indicates that we should all start in right now and stretch all of our oil by saving."

There may be local shortages or spotty conditions in the fuel oil situation this winter, according to McIntosh, because the oil industry is "running so close to capacity." "We need a bit more margin," he said, "and it is within the power of our people to provide this margin by conservation."



On your way old man Downtime!

The double ball thrust motor ups tube cleaning speed at the cutter head—where speed counts! The front ball thrust bearing overcomes friction caused by pull of the self-feeding cutter head. The rear bearing takes out the rotor drag caused by the operator having to force the cleaner against heavy coke.

When this fiendish character shows up to plant his feet on your pay stream profits, chase him away quickly by calling in Lagonda 1100 Series tube cleaners. These coke-killers move swiftly into action, zipping and clawing their way through the gummiest or hardest deposits and bringing your still back on stream in the fastest possible time. There are some mighty good reasons behind these high performance standards as the illustrations show.

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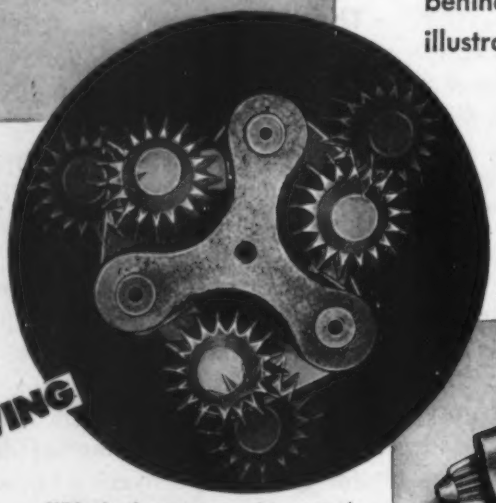

With the largest expansion ever obtained in a swing-frame head, the new Lagonda 3300 Series swing-frame cutter head is going places. It can handle a greater range of tubes and coke conditions and often eliminates the need to change heads in the middle of a cleanout. Seven sizes to accommodate a size range of 2¼ in. to 6 in.

No threaded cutter pins to break, in the new Lagonda 3300 Series swing-frame cutter head. A "keeper" locks the cutter pin firmly — no loosening under service vibration to cause a time-consuming break in the middle of a cleanout. This feature adds life to your cleaners, cuts time on your cleanouts.

Y-271

LAGONDA 1100 SERIES TUBE CLEANERS

Where Does the Sulfur Go?

M. J. FOWLE and R. D. BENT
The Atlantic Refining Company, Philadelphia

THIS paper presents the distribution of sulfur in the products when processing sour crude by: distillation, thermal viscosity breaking, gas-oil cracking, and reforming; catalytic cracking; catalytic desulfurization; and chemical treating. A summary of product quality by three different methods of crude processing is included.

This paper was presented to a Division of Refining Group before the American Petroleum Institute annual meeting early this month in Chicago.

THE current trend in availability of crudes is forcing an increasing number of refiners to process high-sulfur crude oils. When considering the processing of high-sulfur crude, one of the first problems faced is: "Where does the sulfur go?" The answer to this question is essential in order to define and solve process and final product-quality problems. The aim of this paper is to present information on the distribution of sulfur for various types of petroleum processing. The types of processing considered range from the simplest thermal cracking operation to a more complex combination of distillation; desulfurization; thermal viscosity breaking, gas-oil cracking, and reforming; and catalytic cracking.

The major portion of the information to be presented is based on pilot-plant and plant-scale processing of a collection of crude oils known in the terminology of The Atlantic Refining Company as West Texas-New Mexico crude. This mixture contains crudes from the Hobbs, Eunice, Wasson, Russell,

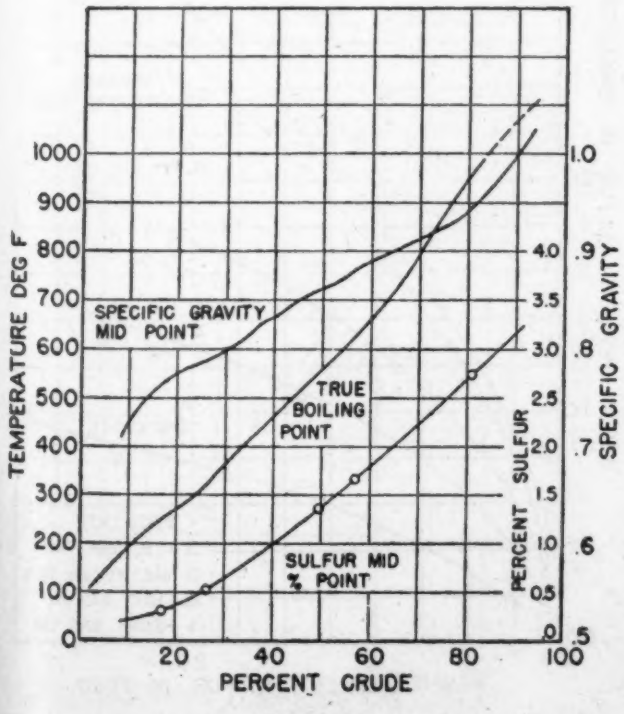

FIGURE 1
Boiling Range, Specific Gravity, and Sulfur Distribution for a Typical West Texas Crude Oil.

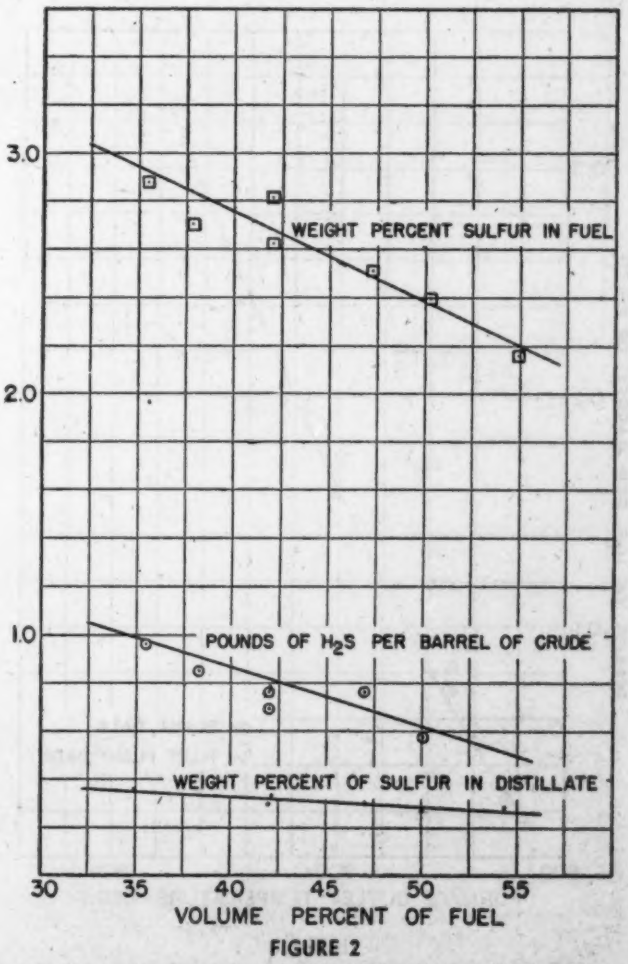

FIGURE 2
Product Sulfur Contents for Thermal Cracking of West Texas Crude Oil.

Slaughter, Seminole, Ector, and Ward-Pecos pools, with Wasson and Seminole predominating. Boiling-range, specific-gravity, and sulfur-content data for a typical West Texas crude mixture are presented in Figure 1. It will be noted that, with the exception of the high-sulfur content and the higher residuum content, this crude is quite similar to East Texas. The West Texas mixture and, more specifically, certain pools in the mix are of interest for the production of lubricants, waxes, and other products. The discussion in this paper, however, is limited to processes for the manufacture of gasoline, and distillate and residual fuel oils.

Primary Processing

Simple Thermal Cracking—The simplest type of processing for the manufacture of gasoline and residual fuel oil is the thermal cracking of the whole crude. The crude oil is charged to the evaporator of a thermal cracking still, and the gas-oil content, together with recycle gas-oil, is condensed in the bottom of the fractionator and charged to the cracking furnace. Data for this operation in a deFlorez-type thermal cracking unit are found in Figure 2. Here the hydrogen-sulfide production, and the sulfur contents of the gasoline and fuel oil, are related to the yield of fuel oil produced. The crude oil charged in this case averaged 1.77 percent sulfur. Thus it can be seen that the major portion of the sulfur remains in the fuel oil;-and, second, that as lower yield (i.e., of lower gravity) fuels are produced, the gas and distillate as well as the fuel oil increase in sulfur content.

Crude Distillation—Crude distillation units vary widely, particularly with respect to the pressure of operation and the number of stages of vaporization

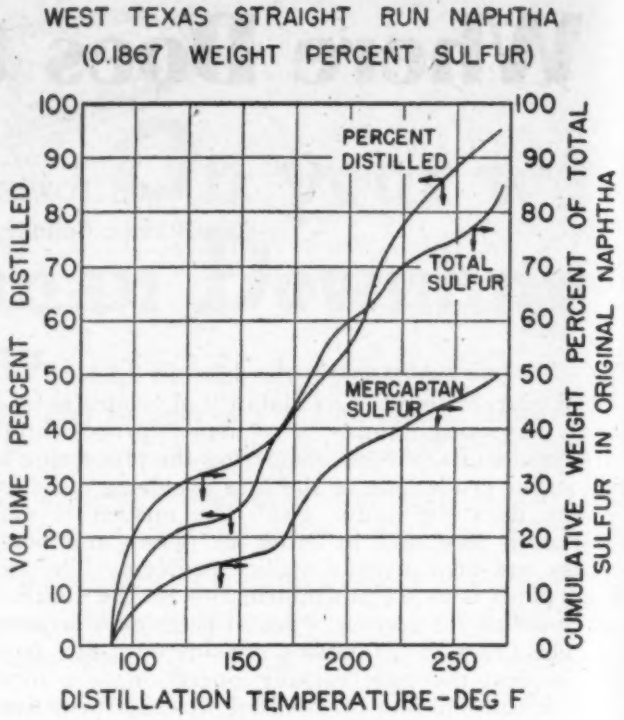

FIGURE 4
Distribution of Sulfur in West Texas Straight-run Naphtha.

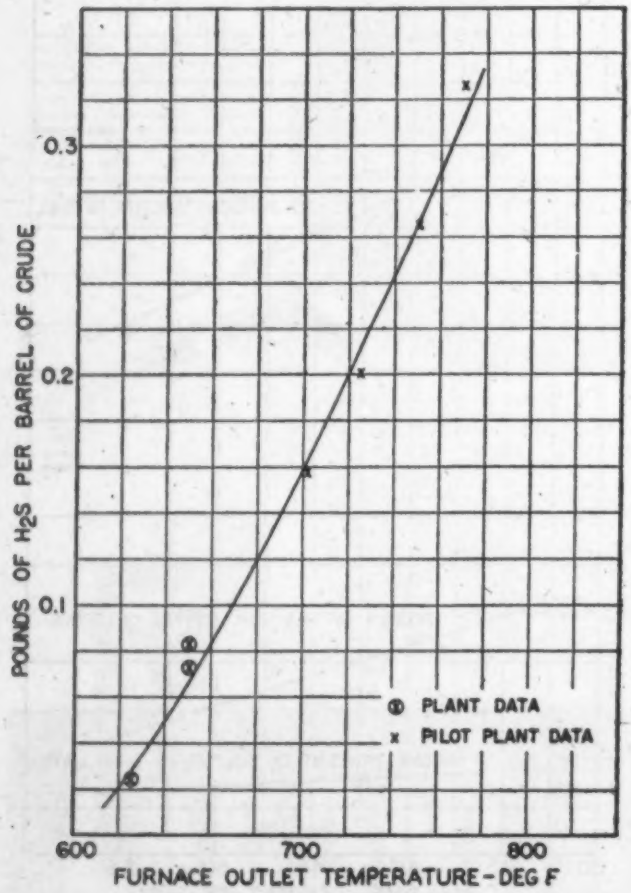

FIGURE 3
Relation between Furnace Conditions and Decomposition of Sulfur Compounds for West Texas Crude-Oil Distillation.

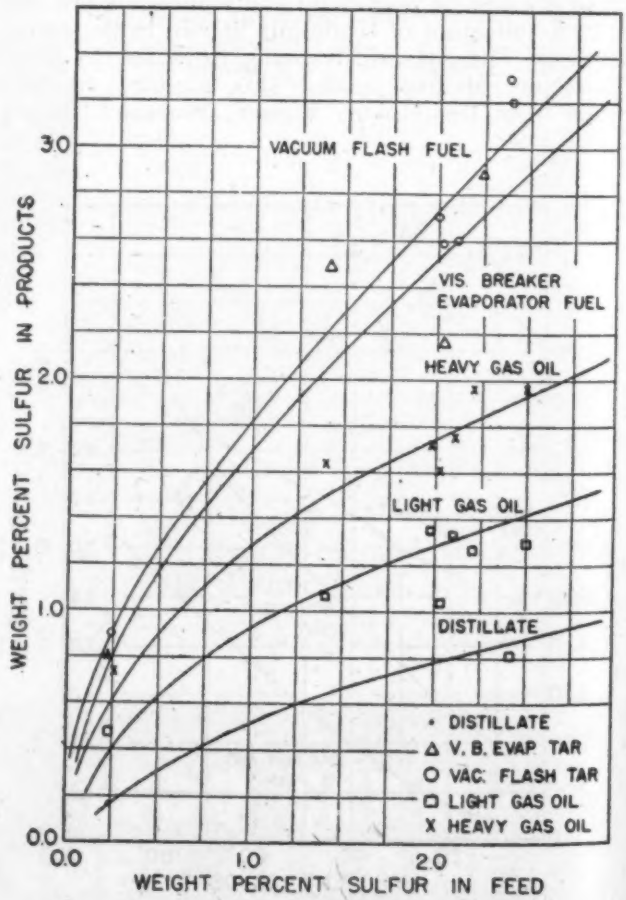

FIGURE 5
Sulfur Content of Products from Viscosity Breaking of High-Sulfur Stocks.

employed. One factor to be considered when planning the distillation of high-sulfur crude is the effect of operating temperature on the decomposition of sulfur compounds. This point is illustrated in Figure 3, which is taken from plant and pilot-plant data on the distillation of West Texas crude. This curve emphasizes the increased decomposition to be expected when higher pipe-still temperatures are employed. The hydrogen-sulfide production is important from the standpoint of equipment corrosion. It should also be borne in mind that the mercaptan contents of the distillate products increase with increasing temperature.

The distribution of mercaptan sulfur and total sulfur for a typical West Texas light straight-run naphtha, produced at a 680° F. pipe-still temperature, is presented in Figure 4. Mercaptan sulfur accounts for more than half of the total sulfur in this stock.

Viscosity Breaking — Viscosity-breaking operations are closely associated with primary distillation, and mild viscosity breaking is extensively used to produce gas-oil feed for catalytic and thermal cracking operations. Sulfur-distribution data for a mild viscosity-breaking-vacuum-flashing operation will be found in Figure 5. The most outstanding point in the viscosity breaking of high-sulfur stocks is the high-sulfur content of the naphtha produced. Fortunately the yield of this gasoline can be held down to 5 to 10 percent by employing mild cracking conditions. Fuel-oil yield is reduced by employing a vacuum-flash operation. Sulfur-distribution data for a moderately high-sulfur viscosity-breaker gasoline are shown in Figure 6.

Reforming—Thermal reforming of straight-run naphtha accomplished about a 45-percent desulfurization, as shown in Figure 7. The extent of desulfurization varies somewhat with the cracking severity, but there were not sufficient data available to include this factor. The data presented represent an average cracking severity equivalent to 10 percent C_3 and lighter gas production.

Thermal Gas-Oil Cracking—As in the case of crude-oil cracking, Figure 8 shows that a large portion of the sulfur in recycle gas-oil cracking remains in the fuel oil. The distribution of total sulfur and mercaptan sulfur, with boiling range for a typical thermal cracked naphtha, is illustrated in Figure 9. Mercaptans represent about 50 percent of the total sulfur content up to a 300° F. boiling point. The high-boiling fractions contain increasingly greater quanti-

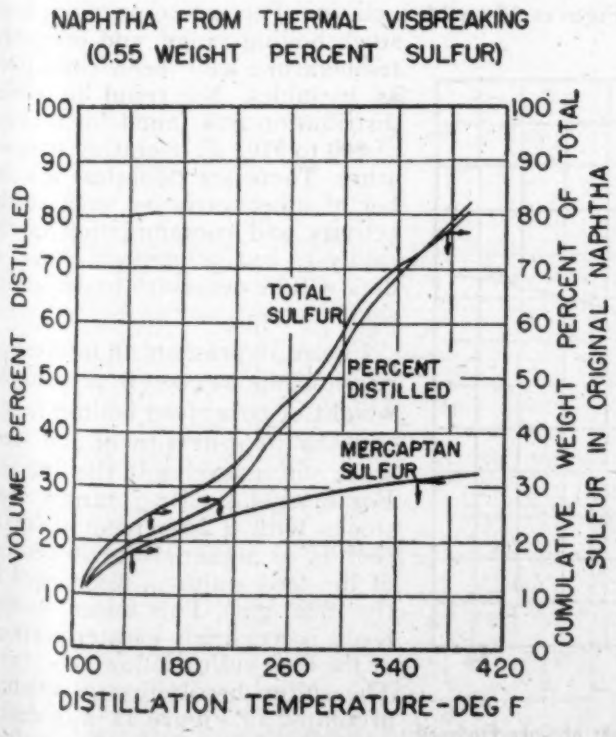

FIGURE 6
Distribution of Sulfur in Viscosity-broken Gasoline.

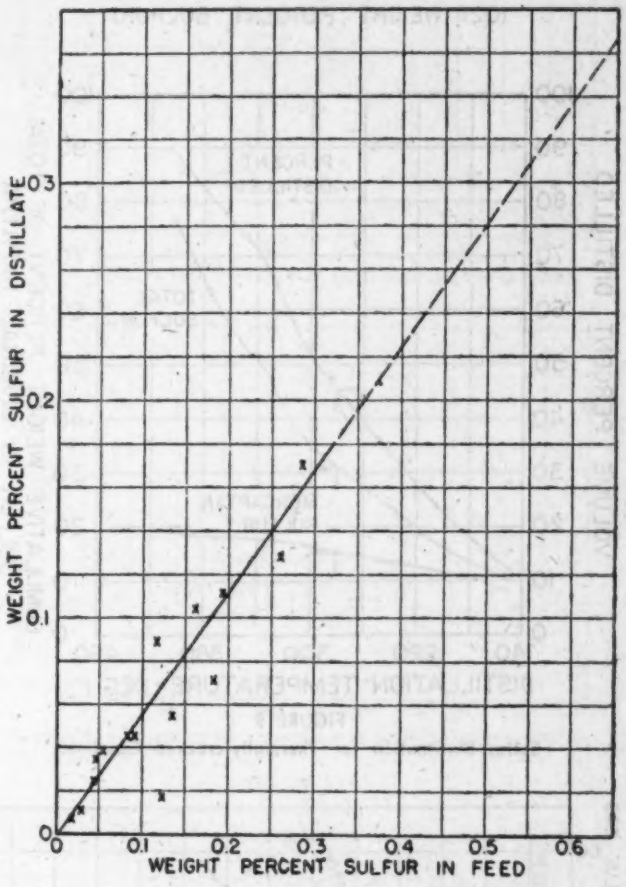

FIGURE 7
Relation between Feed and Product Sulfur Contents for Reforming Straight-run Naphtha.

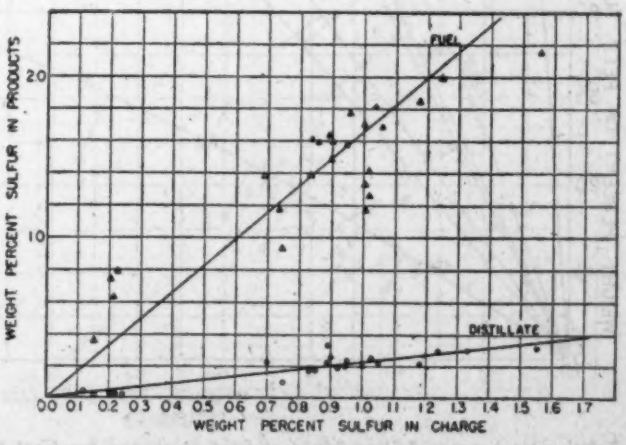
WEIGHT PERCENT SULFUR IN PRODUCTS
FUEL
DISTILLATE
10
20
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17
WEIGHT PERCENT SULFUR IN CHARGE

FIGURE 8
Sulfur Content of Products from Thermal Cracking of Gas Oils.

ties of sulfur compounds, very little of which is of mercaptan type.

Catalytic Cracking—Sulfur distribution for catalytic cracking differs considerably from that for thermal operations. The three chief differences are: An outlet exists for sulfur to leave the system in the regenerator flue gas; no such outlet exists in thermal cracking. Little or no mercaptan sulfur is produced; catalytic gasolines range from zero to 0.01 percent by weight of mercaptan sulfur. Polymerization of sulfur compounds is not a factor as in thermal cracking, and cycle-stock fractions do not contain significantly more sulfur than corresponding fractions in the feed; apparently the sulfur which is polymerized tends to leave the system as coke on the catalyst.

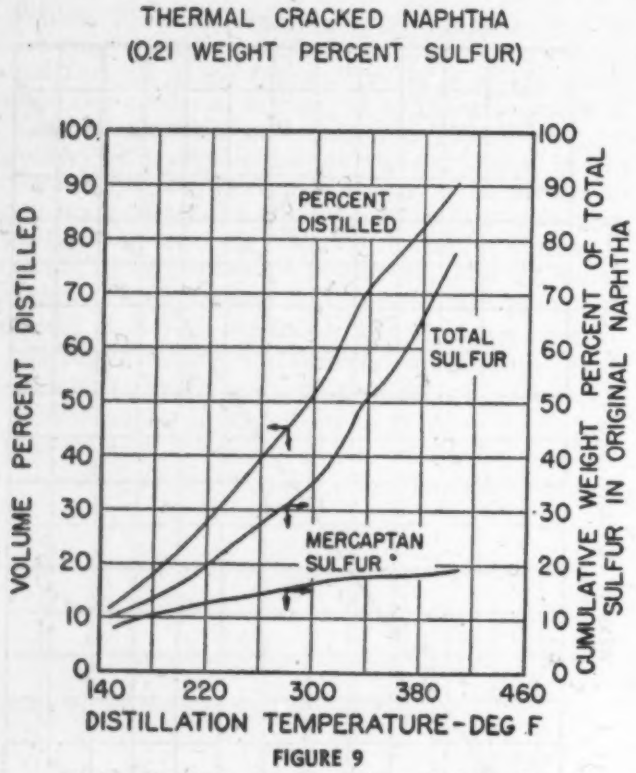

FIGURE 9

Sulfur Distribution for Thermally-cracked Gasoline.

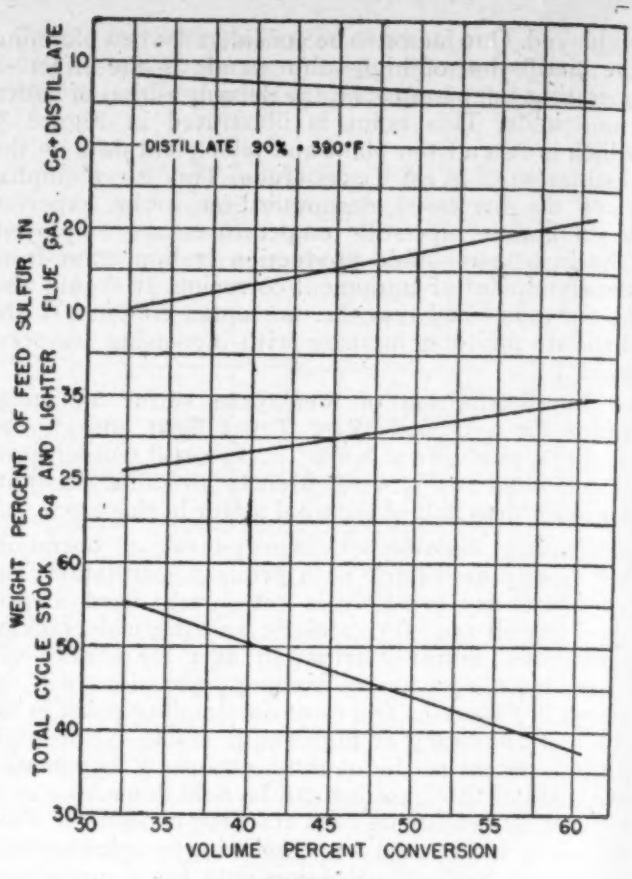

FIGURE 11

Correlation for Distribution of Sulfur in Products from Fluid Catalyst Cracking.

Available sulfur-distribution data for fluid catalyst cracking of a wide variety of stocks with synthetic catalyst have been correlated, and are presented in Figures 10 to 14, inclusive. Percent conversion, feedstock boiling range, and operating temperature have been considered as variables. No trend in sulfur distribution was found for a range of 800 to 970° F. operating temperature. There are doubtless a number of other variables such as the activity and contamination of the catalyst, but a greater range of data will be necessary to determine such factors.

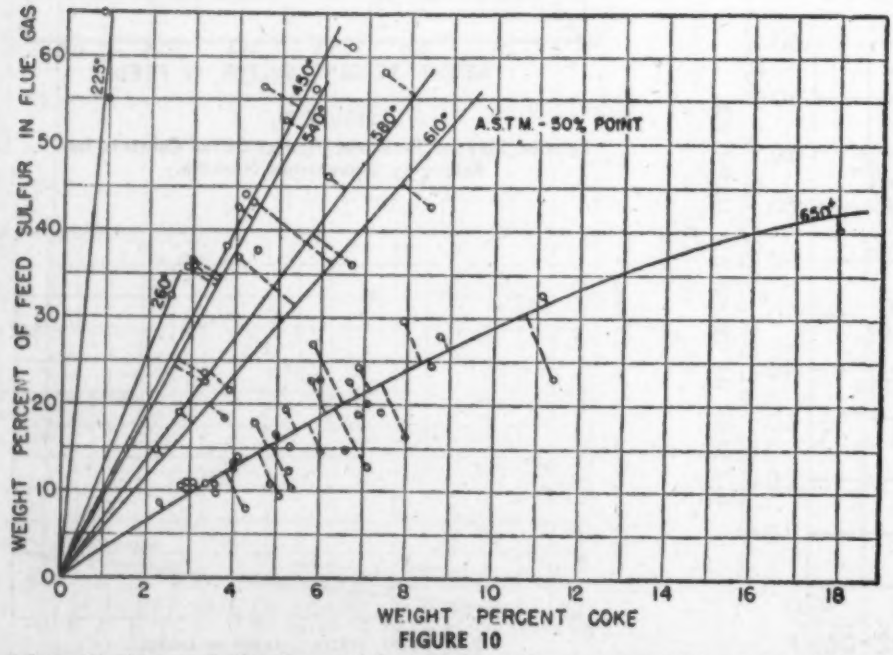

FIGURE 10

Relationship between Boiling Range of Feed Stock and Per Cent by Weight of Coke Produced, with the Proportion of Feed Sulfur Content Discharged in the Flue Gas of a Fluid Catalyst Cracking Operation.

Figure 10 presents an interesting relationship between percent by weight of coke, feed boiling range, and the proportion of the feedstock sulfur leaving in the flue gas. For normal boiling-range feed stocks with a 50-percent point at 650° F. or higher, 10 to 20-percent of the feed sulfur is discharged in the flue gas. For lower boiling feeds, increasingly greater portions of the feed sulfur follow this route. The sulfur-distribution correlation presented in Figure 11 was developed for normal boiling-range feed stocks, viz., with the 50-percent

point at 650° F. and higher. It should be noted that the sulfur data are presented in a different manner from those in the preceding charts; i.e., percent by weight of the total feed sulfur in the individual products is used rather than the sulfur content of the product. Figures 12 and 13 indicate the prediction accuracy of the sulfur-distribution correlation. The correlation in Figure 11 is based on cutting a 390° F. 90-percent-point catalytic gasoline. The variation of gasoline sulfur content with changes in cut point is shown in Figure 14.

Total sulfur distribution for a catalytically cracked gasoline is shown in Figure 15. No mercaptan-distribution data are included, as the mercaptan content is negligible.

Treating Operations

From the sulfur standpoint, treating of gasoline and distillate fuels is carried out for one or more of the following reasons:

1. Reduction of total sulfur content.
2. Removal of corrosive sulfur compounds.
3. Improvement of odor.
4. Improvement of tetraethyl-lead susceptibility.

The oldest treating process still in widespread use is the doctor process for the oxidation of mercaptans to disulfides. This process accomplishes an improvement in odor and corrosive sulfur content with no sulfur reduction, unless practiced in conjunction with vacuum rerunning. Numerous other processes are in general use to accomplish the same purposes as doctor sweetening. Generally, sweetening causes a loss in clear octane number, with no change in tetraethyl-lead susceptibility.

Mercaptan Extraction—High-sulfur straight-run and thermally cracked gasolines contain appreciable mercaptan sulfur; and most modern refineries practice some form of mercaptan extraction, primarily for the

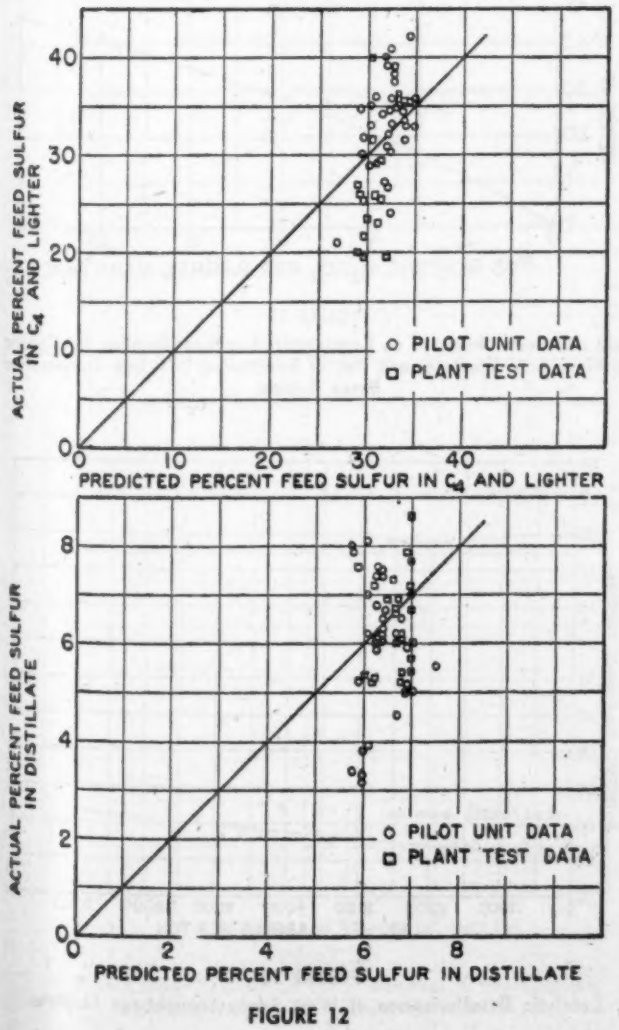
ACTUAL PERCENT FEED SULFUR IN C_4 AND LIGHTER
PREDICTED PERCENT FEED SULFUR IN C_4 AND LIGHTER
ACTUAL PERCENT FEED SULFUR IN DISTILLATE
PREDICTED PERCENT FEED SULFUR IN DISTILLATE
O PILOT UNIT DATA
□ PLANT TEST DATA

FIGURE 12

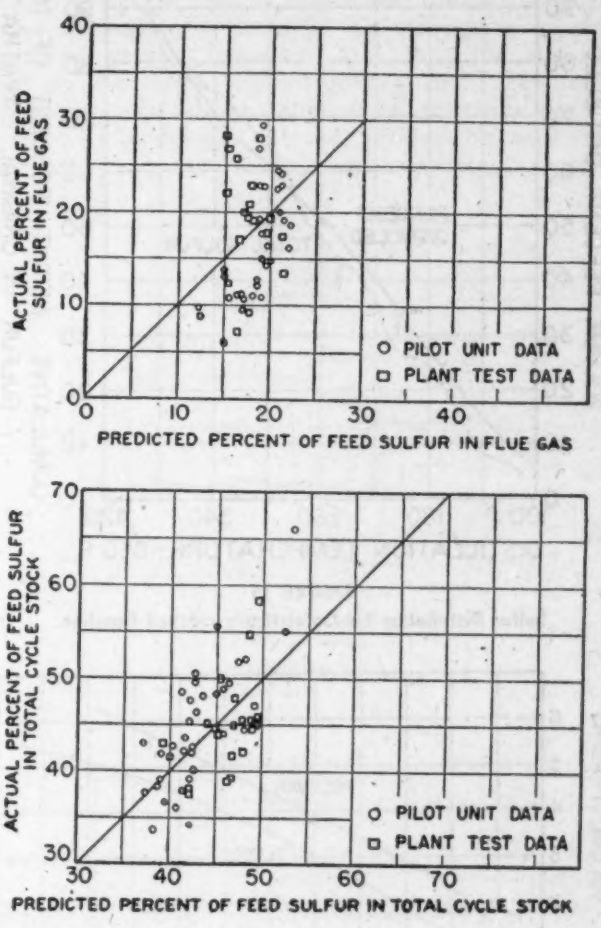
ACTUAL PERCENT OF FEED SULFUR IN FLUE GAS
PREDICTED PERCENT OF FEED SULFUR IN FLUE GAS
ACTUAL PERCENT OF FEED SULFUR IN TOTAL CYCLE STOCK
PREDICTED PERCENT OF FEED SULFUR IN TOTAL CYCLE STOCK
O PILOT UNIT DATA
□ PLANT TEST DATA

FIGURE 13

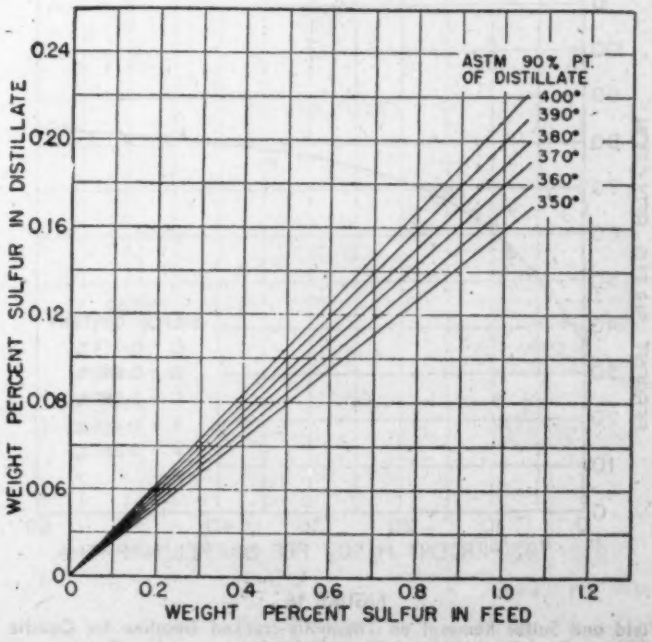

FIGURE 14

Effect of Cut Point on Sulfur Content of Catalytically-cracked Gasoline.

improvement in tetraethyl-lead susceptibility and the avoidance of the octane-number loss which takes place when sweetening. The simplest type of mercaptan-extraction process is a counter-current regenerative extraction with aqueous caustic. Such processing accomplishes a 25 to 60 percent mercaptan removal, depending on the feed stock (proportion of low molecular-weight mercaptans) and the equipment. More advanced mercaptan-extraction processes employing selective solvents, such as the Unisol process[1] and others,[2] accomplish 95 percent or more

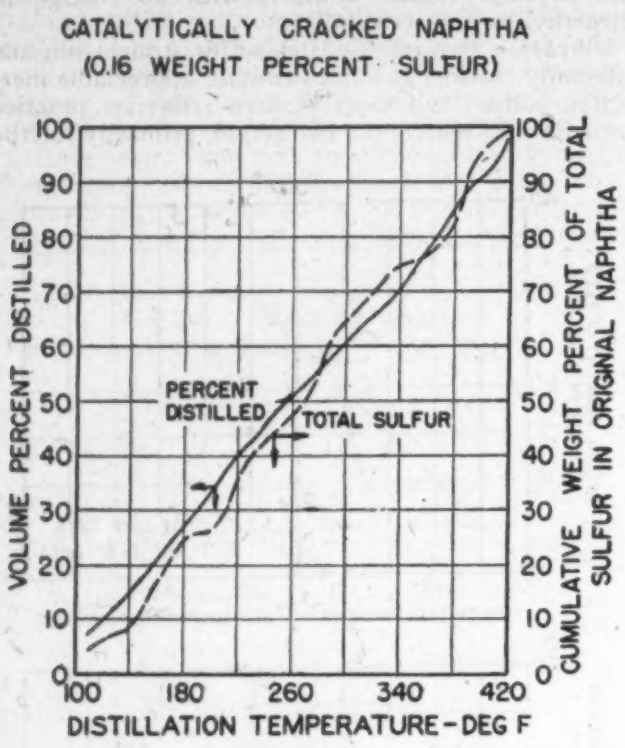
CATALYTICALLY CRACKED NAPHTHA
(0.16 WEIGHT PERCENT SULFUR)
VOLUME PERCENT DISTILLED
CUMULATIVE WEIGHT PERCENT OF TOTAL SULFUR IN ORIGINAL NAPHTHA
PERCENT DISTILLED
TOTAL SULFUR
DISTILLATION TEMPERATURE - DEG F

FIGURE 15
Sulfur Distribution for Catalytically-cracked Gasoline.

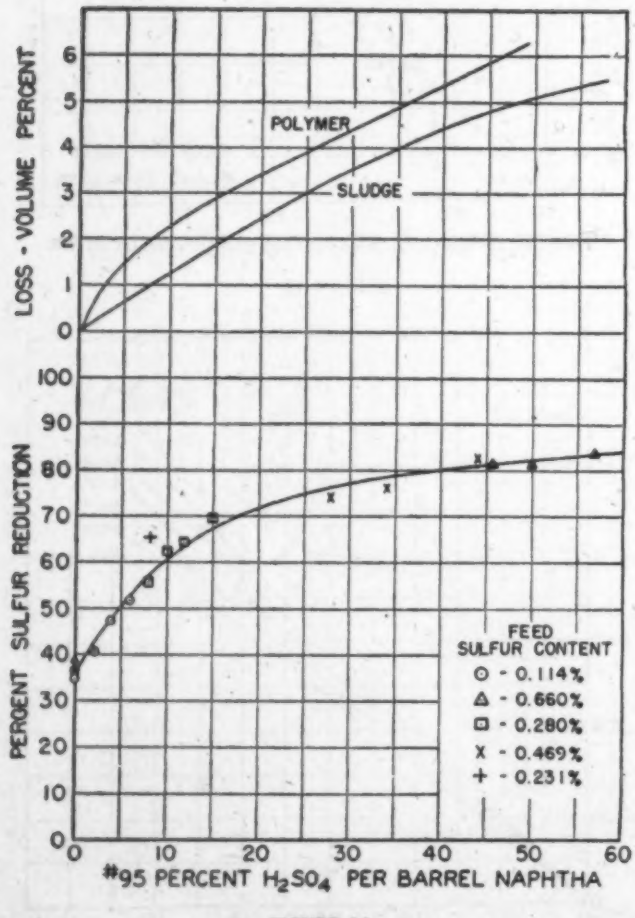

FIGURE 16
Yield and Sulfur Removal on Thermally-cracked Gasoline for Caustic Washing, Acid Treating, and Doctor Sweetening in a Low-Temperature Rerun System.

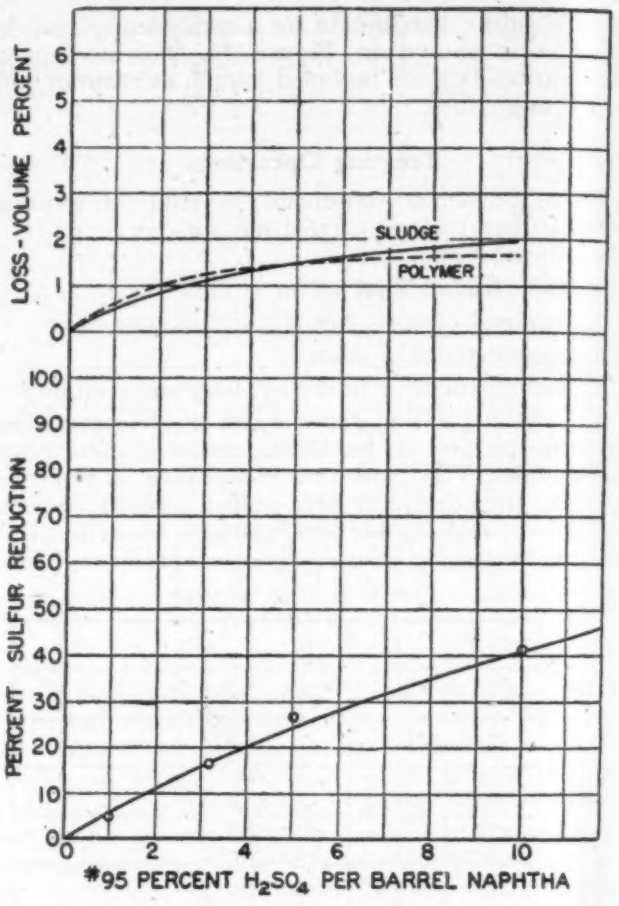

FIGURE 17
Yield and Sulfur Removal on Catalytically-cracked Gasoline for Caustic Washing, Acid Treating, and Doctor Sweetening in a Low-Temperature Rerun System.

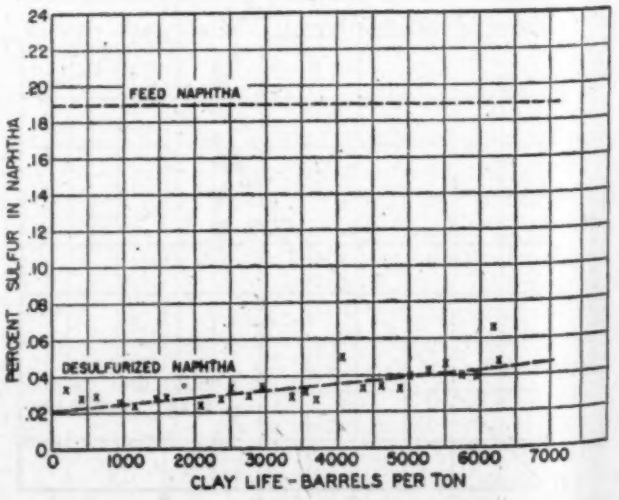

FIGURE 18
Catalytic Desulfurization of West Texas Straight-run Naphtha.

extraction of mercaptans. Mercaptan extraction meets all four treating aims listed previously herein. In general, mercaptan extraction of higher boiling distillate fuels is not very effective.

Acid Treating—Sulfuric-acid extraction of sulfur compounds is extensively practiced, particularly for high-sulfur thermally cracked gasolines. Such processing generally necessitates a rerunning operation to remove the polymers formed. It has been found that, by combining sulfuric-acid treating with doctor sweetening and low-temperature vacuum rerun, the sulfur removal can be increased considerably over conventional acid treating. This increase in sulfur removal results from the fact that the disulfides formed are much higher boiling than their corresponding mercaptans. Figure 16 presents data on yield loss to sludge, polymer production, and sulfur removal for a treating system consisting of caustic

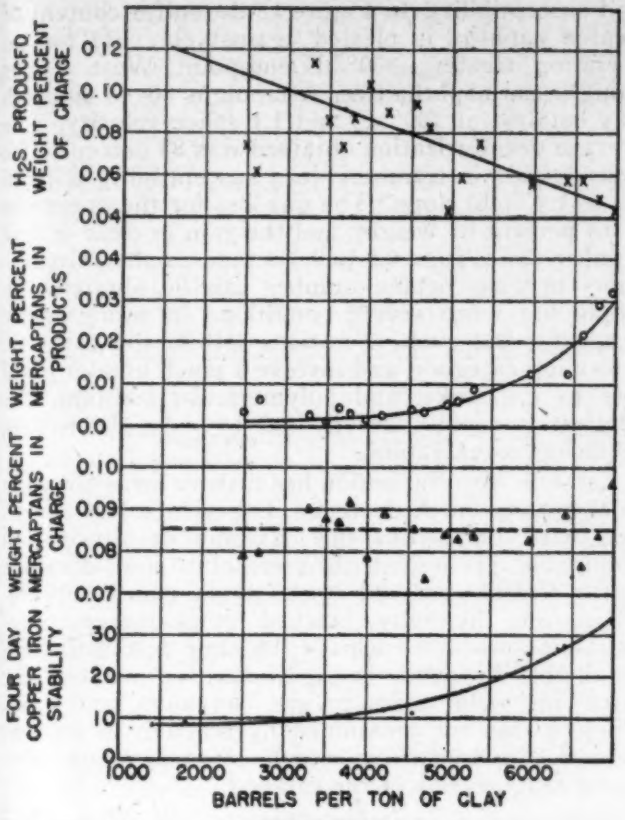
H2S PRODUCED WEIGHT PERCENT OF CHARGE
WEIGHT PERCENT MERCAPTANS IN PRODUCTS
WEIGHT PERCENT MERCAPTANS IN CHARGE
FOUR DAY COPPER IRON STABILITY
BARRELS PER TON OF CLAY

FIGURE 19
Catalytic Desulfurization of West Texas Furnace Oil.

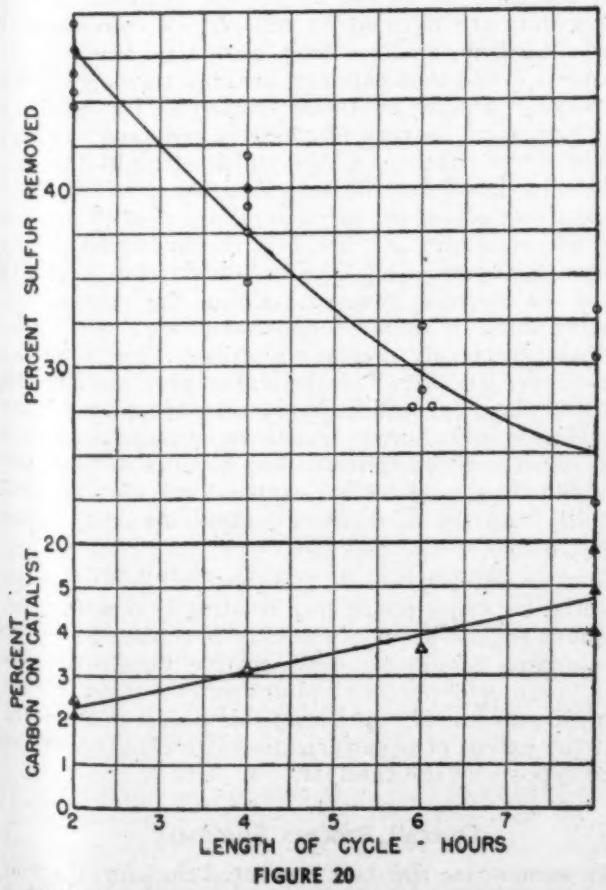

FIGURE 20
Effect of Carbon Deposit on Sulfur Removal in the Catalytic Desulfurization of West Texas Furnace Oil.

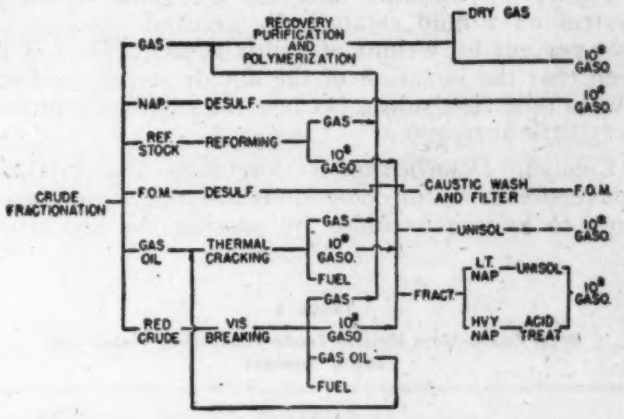

FIGURE 21

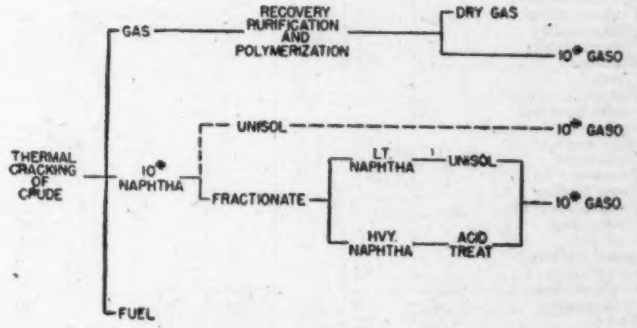

FIGURE 22

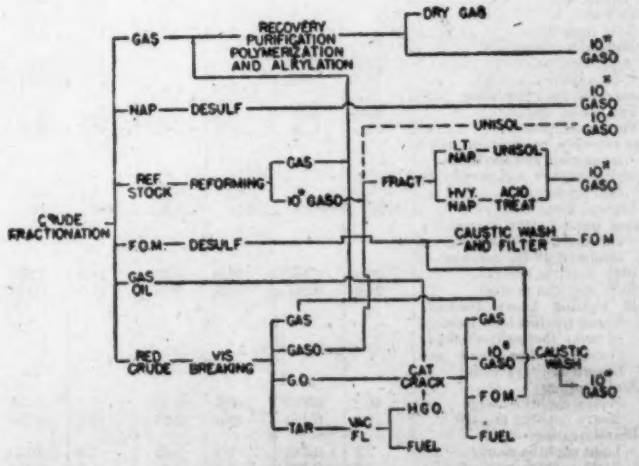

FIGURE 23

washing, acid treating, doctor sweetening, and steam and vacuum rerunning. It is notable that, for the typical thermally cracked stocks treated, approximately 35 percent of the sulfur is removed by caustic washing, doctor sweetening, and low-temperature rerun. Thus, if an acid-treating rerun system is justified for reasons other than sulfur removal (for gum reduction or improvement of stability), it is well worth considering the economics of including a doctor-sweetening and low-temperature-rerun step. When rerunning doctor-sweetened gasoline, temperatures should be held below 215° F., and hold-up time at 215° F. minimized. It can also be seen in Figure 16 that sulfur removal increases very slowly above about 70 percent removal and 20 pounds of acid per barrel. For greater removal, higher strength acid and/or low-temperature treating must be considered.[3]

Figure 17 contains data for a similar treating system on a fluid catalytically cracked gasoline of 0.24 percent by weight of sulfur content. Here it is seen that the inclusion of the doctor step is ineffective in removing sulfur, because the gasoline contains very little mercaptan.

Catalytic Desulfurization—Naphthas—The catalytic conversion of sulfur compounds in straight-run gasolines to hydrogen sulfide by passing the vaporized product at elevated temperatures over clay, bauxite, or other catalysts has been practiced for many years—primarily for the improvement of tetraethyl-lead susceptibility. In Figure 18 the sulfur content of treated naphtha is plotted against clay life for an operation treating 300° F.-end-point West Texas straight-run naphtha over Attapulgus 30- to 60-mesh clay catalyst at 750° F. and 1.1 space velocity. The average desulfurization obtained was 83 percent. The average gain in tetraethyl-lead susceptibility is from 0.9 to 1.9 Hebl slope.[4] The gas loss for the operation is 0.4 percent by weight, and the gain in clear octane number varies from 0.2 to 0.6 octane number. Greater gains in clear octane number can be obtained by employing more severe conditions or more active catalysts; but such operations fall in the catalytic reforming category, and involve a much greater yield loss to gas, coke, and polymers. In addition, the catalyst is rapidly deactivated by coke deposition, requiring regeneration.

Catalytic desulfurization has little or no application to thermally cracked stocks. Experience has shown that, with such stocks, the maximum desulfurization obtainable is limited to mercaptan and disulfide sulfur (freshly cracked stocks contain no disulfide). Thus, for thermally cracked stocks, mercaptan-extraction processes achieve the same desulfurization obtainable by catalytic desulfurization without the attendant yield losses to gas, polymers, and coke. These losses are occasioned by reaction of the unsaturated hydrocarbons which, in turn, require frequent regeneration of the catalyst.

Catalytic Desulfurization—Furnace Oil—High-sulfur furnace oils contain corrosive sulfur compounds which cause considerable difficulty with corrosion and plugging in domestic burner systems. These compounds are difficult to remove by conventional doctor treating, acid treating, or caustic washing. It has been found that vapor-phase clay treating, under conditions similar to those employed for naphtha desulfurization, is very effective in reducing the corrosive sulfur content of high-sulfur straight-run furnace oils. Data for the desulfurization of an 0.85-percent sulfur-content furnace oil are plotted against clay life in Figure 19. Based on the hydrogen sulfide produced, the extent of the desulfurization averages about 10 percent removal. From the mercaptan-content data, it may be concluded that the sulfur removed is largely mercaptan sulfur. The "four-day iron-copper stability" is the value obtained by the Atlantic chemical stability of furnace-oil test method.[5] Correlation with burner test work, storage tests, and field experience has shown that a value of 15 is acceptable. It should be noted that both the chemical stability and the mercaptan content break at about 4500-barrels-per-ton clay life.

Greater desulfurization of furnace-oil boiling-range material by vapor-phase clay treating is possible, but frequent regeneration of the clay is required. Figure 20 contains laboratory regenerative desulfurization data for a 0.93-percent sulfur-content West Texas straight-run furnace oil. From this plot it is apparent that the extent of desulfurization is a function of the coke deposit on the catalyst.

TABLE 1

West Texas-New Mexico Crude Processing Yields and Sulfur Content

	CASE 1		CASE 2		CASE 3	
	Barrels	Percent by Wt. of Sulfur	Barrels	Percent by Wt. of Sulfur	Barrels	Percent by Wt. of Sulfur
Crude Fractionation:						
Crude-oil charge	100.0	1.81	.....	.....	100.0	1.81
10-lb naphtha	21.1	0.21	.....	.....	21.1	0.21
Reformer stock	12.5	0.56	.....	.....	9.0	0.51
Furnace oil	23.5	1.23	.....	.....	10.0	0.81
Gasoil	5.0	1.80	.....	.....	22.0	1.46
Reduced Crude	38.0	3.02	.....	.....	38.0	3.02
Viscosity breaking:						
Reduced-crude charge	38.0	3.02	.....	.....	38.0	3.02
10-lb. gasoline	3.6	1.0	.....	.....	3.6	1.0
Light gasoil	13.2	1.60	.....	.....	13.2	1.60
Evaporated tar	21.4	3.43	.....	.....	21.4	3.43
Vacuum flashing:						
Evaporated-tar charge	.....	.....	.....	.....	21.4	3.43
Heavy gasoil	.....	.....	.....	.....	8.0	2.30
Fuel oil	.....	.....	.....	.....	13.4	4.04
Thermal cracking:						
Gasoil charge	18.2	1.67	.....	.....	.....	.....
Crude oil charge	.....	.....	100.0	1.81	.....	.....
10-lb. gasoline	9.3	0.37	56.3	0.36	.....	.....
Fuel oil	7.9	2.80	32.2	3.04	.....	.....
Reforming:						
Reformed-stock charge	12.5	0.56	.....	.....	9.0	0.51
10-lb. gasoline	11.1	0.315	.....	.....	7.9	0.287
Catalytic cracking:						
Gasoil charge	.....	.....	.....	.....	43.2	1.67
10-lb. gasoline	.....	.....	.....	.....	15.3	0.40
Furnace oil	.....	.....	.....	.....	15.8	1.33
Fuel oil	.....	.....	.....	.....	5.2	1.89
Coke (pounds)	.....	.....	.....	.....	825	4.55
Naphtha desulfurization:						
10-lb. naphtha charge	21.1	0.21	.....	.....	21.1	0.21
10-lb. naphtha product	21.1	0.042	.....	.....	21.1	0.042
Furnace-oil desulfurization:						
Furnace-oil charge	23.5	1.23	.....	.....	10.0	0.81
Furnace-oil product	23.5	1.13	.....	.....	10.0	0.69
Gas recovery, purification, polymerization, and alkylation:						
10-lb. polymer and/or alkylation product	1.0	0.10	4.8	0.10	4.7	0.10
Dry gas (pounds)	1093	8.08	2561	23.5	1402	10.6
Unisol treating total thermally-cracked, viscosity-broken, and reformed 10-lb. gasoline:						
10-lb. naphtha charge	24.0	0.437	56.3	0.36	11.5	0.502
10-lb. naphtha product	24.0	0.357	56.3	0.25	11.5	0.410
Acid treating heavy fraction, Unisol treating light fraction of total thermally-cracked, viscosity-broken, and reformed 10-lb. gasoline:						
Acid treating:						
Heavy naphtha charge	21.2	0.425	49.5	0.36	10.2	0.478
Heavy naphtha product	21.0	0.290	49.0	0.25	10.1	0.326
Unisol treating:						
Light naphtha charge	2.8	0.543	6.8	0.33	1.3	.0739
Light naphtha product	2.8	0.122	6.8	0.07	1.3	0.176

Overall Process Summary

To summarize the data presented thus far, three of the many possible methods of completely processing West Texas crude to fuel products are shown in ac-

TABLE 2

West Texas-New Mexico Crude-Processing, Over-All-Product-Yield, Octane-Number, and Sulfur Data

	CASE 1					
	Acid-Treated			Unisol-Treated		
STREAM	Volume Bbls. Per 100 Bbl of Crude	CFR Research Octane No. Without Addition of Tetraethyl Lead	Sulfur Percent by Weight	Volume Bbls. Per 100 Bbl. of Crude	CFR Research Octane No. Without Addition of Tetraethyl Lead	Sulfur Percent by Weight
Desulfurized straight-run naphtha...	21.1	61.1	0.042	21.1	61.1	0.042
Reformed gasoline	11.0	66.4		11.1	67.8	
Viscosity-broken gasoline	3.6	70.9	0.273	3.6	72.3	0.357
Thermally-cracked gasoline	9.2	76.8		9.3	78.2	
Polymer or alkylate	1.0	110	0.10	1.0	110	0.10
Total 10-lb gasoline	45.9	Without addition of TEL.....67.4 With addition of 1 ml TEL per gal.....76.1 With addition of 2 ml TEL per gal.....79.6	0.165	46.1	Without addition of TEL.....68.1 With addition of 1 ml TEL per gal.....76.5 With addition of 2 ml TEL per gal.....79.9	0.210
Furnace oil	23.5	.....	1.13	.....	.....	.....
Fuel oil	29.3	.....	3.28	.....	.....	.....

TABLE 3

West Texas-New Mexico Crude-Processing, Over-All-Product-Yield, Octane-Number, and Sulfur Data

	CASE 2					
	Acid-Treated			Unisol-Treated		
STREAM	Volume Bbls. Per 100 Bbl. of Crude	CFR Research Octane No. Without Addition of Tetraethyl Lead	Sulfur Percent by Weight	Volume Bbls. Per 100 Bbl. of Crude	CFR Research Octane No. Without Addition of Tetraethyl Lead	Sulfur Percent by Weight
Desulfurized gasoline	55.8	68.4	0.230	56.3	69.8	0.250
Polymer or alkylate	4.8	110	0.10	4.8	110	0.10
Total 10-lb. gasoline	60.6	Without TEL addition 71.7 With addition of 1 ml TEL per gal.....79.6 With addition of 2 ml TEL per gal.....82.8	0.220	61.1	Without TEL addition 73.0 With addition of 1 ml TEL per gal.....80.4 With addition of 2 ml TEL per gal.....83.7	0.239
Fuel oil	32.2	.....	3.04	.....	.....	.....

TABLE 4

West Texas-New Mexico Crude-Processing, Over-All-Product-Yield, Octane-Number, and Sulfur Data

	CASE 3					
	Acid-Treated			Unisol-Treated		
..STREAM	Volume Bbls. Per 100 Bbl of Crude	CFR Research Octane No. Without Addition of Tetraethyl Lead	Sulfur Percent by Weight	Volume Bbls. Per 100 Bbl. of Crude	CFR Research Octane No. Without Addition of Tetraethyl Lead	Sulfur Percent by Weight
Desulfurized straight-run naphtha...	21.1	61.1	0.042	21.1	61.1	0.042
Reformed gasoline	7.8	66.9		7.9	68.3	
Viscosity-broken gasoline	3.6	70.9	0.312	3.6	72.3	0.410
Polymer or alkylate	4.7	110	0.10	4.7	110	0.10
Catalytically-cracked gasoline	15.3	94.3*	0.40	15.3	94.3*	0.40
Total 10-lb. gasoline	52.5	Without TEL addition 79.2 With addition of 1 ml TEL per gal.....85.3 With addition of 2 ml TEL per gal.....87.8	0.214	52.6	Without TEL addition 79.5 Without addition of 1 ml TEL per gal.....85.4 With addition of 2 ml TEL per gal.....87.8	0.235
Furnace oil	25.8	.....	1.14	.....	.....	.....
Fuel oil	18.6	.....	2.97	.....	.....	.....

* Base octane number of catalytically-cracked gasoline: pool octane number is corrected for increased blend octane number of catalytically-cracked gasoline.

companying Figures 21, 22, and 23. Volume and sulfur-content data for the charge and products in the various operations are shown in Table 1. Yield, octane-number, and sulfur-content data for the final products in the various cases are summarized in Tables 2, 3, and 4. It should be emphasized that no attempt has been made to achieve a direct comparison of catalytic vs. thermal cracking, and that many other variations are possible in cases 1 and 3.

Examining the product summaries, it can be seen that the gasoline produced from West Texas crude varies from 0.15 to 0.25 percent sulfur content, depending to a great extent on the relative yields of gasoline, furnace oil, and residual fuel oil produced. Further, it should be noted that, whereas Unisol treating does not produce as low a sulfur content as the most costly acid-treating operation, the Unisol-treated product is fully competitive from an octane-number value standpoint.

The final choice of the exact processing scheme employed will depend on many factors, but it is hoped that the data presented will narrow the field for those refineries to whom sour crudes are exactly that. For each individual refinery, the ratio of sweet to sour crude and the ratio of motor fuel to distillate and residual fuel oils will pretty definitely set the complexity of processing required to meet the competitive octane-number, sulfur, and other performance specifications.

Acknowledgment

The help of Messrs. J. H. McCullough, B. E. Milner, G. P. Masologites, and W. A. Saylor in preparing the charts and correlations used in this report is gratefully acknowledged.

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Power Plant Design for An Expanding Refinery

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New York

THE Houston Refinery of Shell Oil Company is located on the Houston Ship Channel at a site which offers important advantages for refinery and petro-chemical processing operations.

Crude oil production is available not only from coastal fields but also through pipe lines from the large reserves in East Texas and West Texas. Economical transportation of crude oil is provided via pipe lines, and products are shipped by ocean going tankers, barges and tank cars. Natural gas is readily available for fuel and thereby permits practically all components of the crude oil intake to be processed into marketable finished products.

The refinery was initially operated in 1929 when crude distillation and thermal cracking units were installed. Since that time additional facilities have been constructed to provide increased throughput and more complete processing of the crude charge. The refinery now processes about 100,000 barrels per day of crude oil and produces motor and aviation gasolines, fuel oils, kerosine, diesel oils, solvents, and other petroleum products. A new fluid catalytic cracking unit supplements older thermal cracking units and extensive lubricating oil manufacturing installations are now under construction.

Adjacent to the refinery site, Shell Chemical Corporation in recent years has installed a variety of petro-chemical processing facilities. Shell Chemical processes supplement the petroleum refining plants

Figure 1—Shell's Houston refinery and chemical plants. Operating on a 24-hour basis, the refinery processes 100,000 barrels of crude oil daily. The plant covers an area of 3 square miles. Shell Chemical Corporation plant shows at upper left.

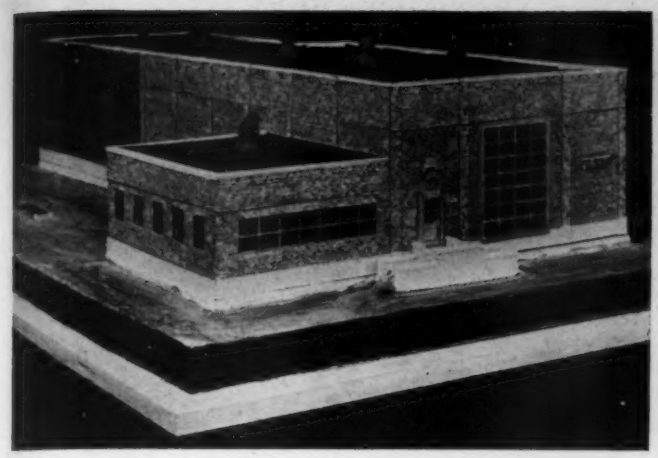

Figure 2—Model showing exterior view of new turbine-generator building.

and utilize by-product gases, formerly consumed as fuel for the production of a large number of petroleum derived chemicals.

Starting with the first commercial butadiene plant in the nation's synthetic rubber program and a plant to supply war-time needs for isopropryl alcohol and acetone, the chemical processes have since been expanded many-fold. New plants are producing other alcohols, ketones, D-D soil fumigant and a number of solvents and intermediate chemicals for the manufacture of surface coatings, plastics and various industrial materials. New large chemical plants under construction include one for the manufacture of synthetic ethyl alcohol and another for synthetic glycerine.

The supply of process steam (at 175-200 psig) and electric power to these many developments lead to the consideration of superimposed turbine generators. The advantages of this type of installation have been realized for many years and in 1936-37 two 2500-KW turbine-generators and accompanying boilers were installed. These were designed for 450 psig and 650° F. steam inlet, 200 psig exhaust and electric power generation at 2300 volts, 3 phase, 60 cycles. They were supplemented by purchased electric power supplied at a primary voltage of 12,000.

MOST refineries having large throughputs and manufacturing a variety of products have reached their present status over a period of years. Plants providing complete processing of crude oil at the time of initial operation are rare, and even where a fairly complete refinery has been built as a single construction project, developments in an expanding industry and changing market conditions have usually brought economic opportunities or necessities that have resulted in the building of additional process units. As a refinery is expanded by the addition of new units, utility requirements rise and initial power plant installations become inadequate to supply the increased demand. Not only must the new power loads be adequately provided, but other factors of operating reliability and convenience of power source at the process units must be carefully weighed along with the realization of economic fuel utilization. The problems are complex, and as variable as the process schemes used by the refineries.

This article presents some of the reasoning underlying the design of a superimposed power plant that was planned to provide the additional power requirements of a greatly expanded petroleum processing installation. The selection of steam pressures, electric power generation and distribution voltages, and the balance between steam and electric drivers for process equipment are fitted to the needs of the specifc refinery considered, but similar principles are applicable to the power plants of process industry generally.

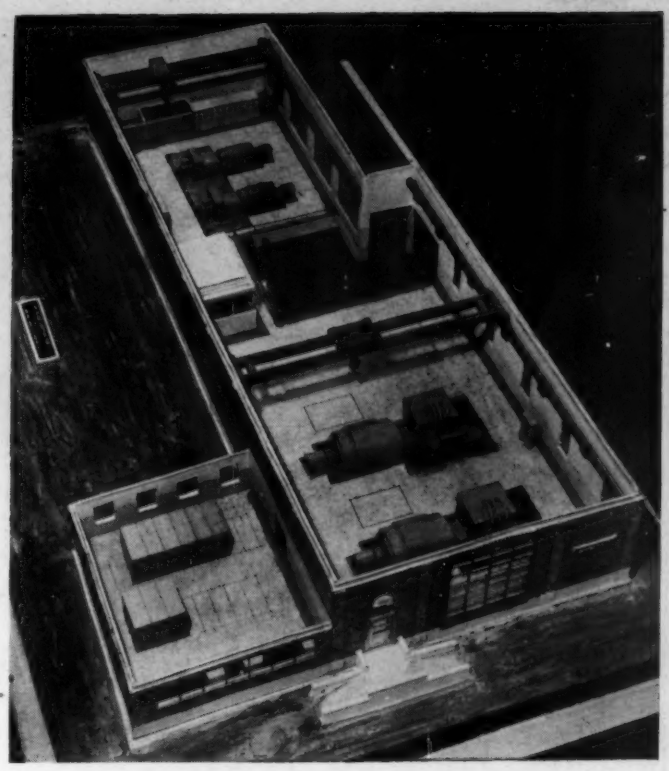

Figure 3—Same model as in Figure 2 with roof removed. Room at left of large generators is switch bay.

As the newer petroleum and chemical processes were developed, electric power requirements were found to be considerably in excess of the power which can be generated by superimposed turbine-generators with inlet steam at 450 psig. A study on the economics of higher pressure turbine-generators resulted in the decision to increase the steam generation pressure in the new extensions to 650 psig, to increase generator and primary distribution voltage from 2300 to 12,000 volts and to re-use the existing 12,000/2300-volt transformer in the rearrangement.

Preliminary plans, completed late in 1945, for the installation of two new turbine-generators were extended in September, 1946, to include a third generator and a total of five new boilers each designed to produce 250,000 pounds per hour. Steam power plant auxiliaries and water treaters are being installed along with the boilers.

In developing the design, a model of the generator building (see Figure 2) was constructed. It serves as a guide for obtaining the most desirable arrangement in connection with operation, accessibility for maintenance and planning of tie-ins between the old and the new.

The same model with roof removed is shown in Figure 3. Two of the three new 10,000-KW turbine-generators are in the right foreground and the smaller existing units are in the background. The design incorporates: an air-conditioned control room, left center; overhead cranes; and work space at ground level with roll-up doors of sufficient size for trucking the largest equipment parts in and out of the building, dark section in center.

The current extensions are shown with heavy lines in Figure 4. Raw water (about 75 percent of the total make-up) is given a sulphuric acid pretreatment for reduction of high bicarbonate alkylinity, aerated for carbon dioxide reduction and then softened in a hot lime process. Heat is supplied to the softeners by the

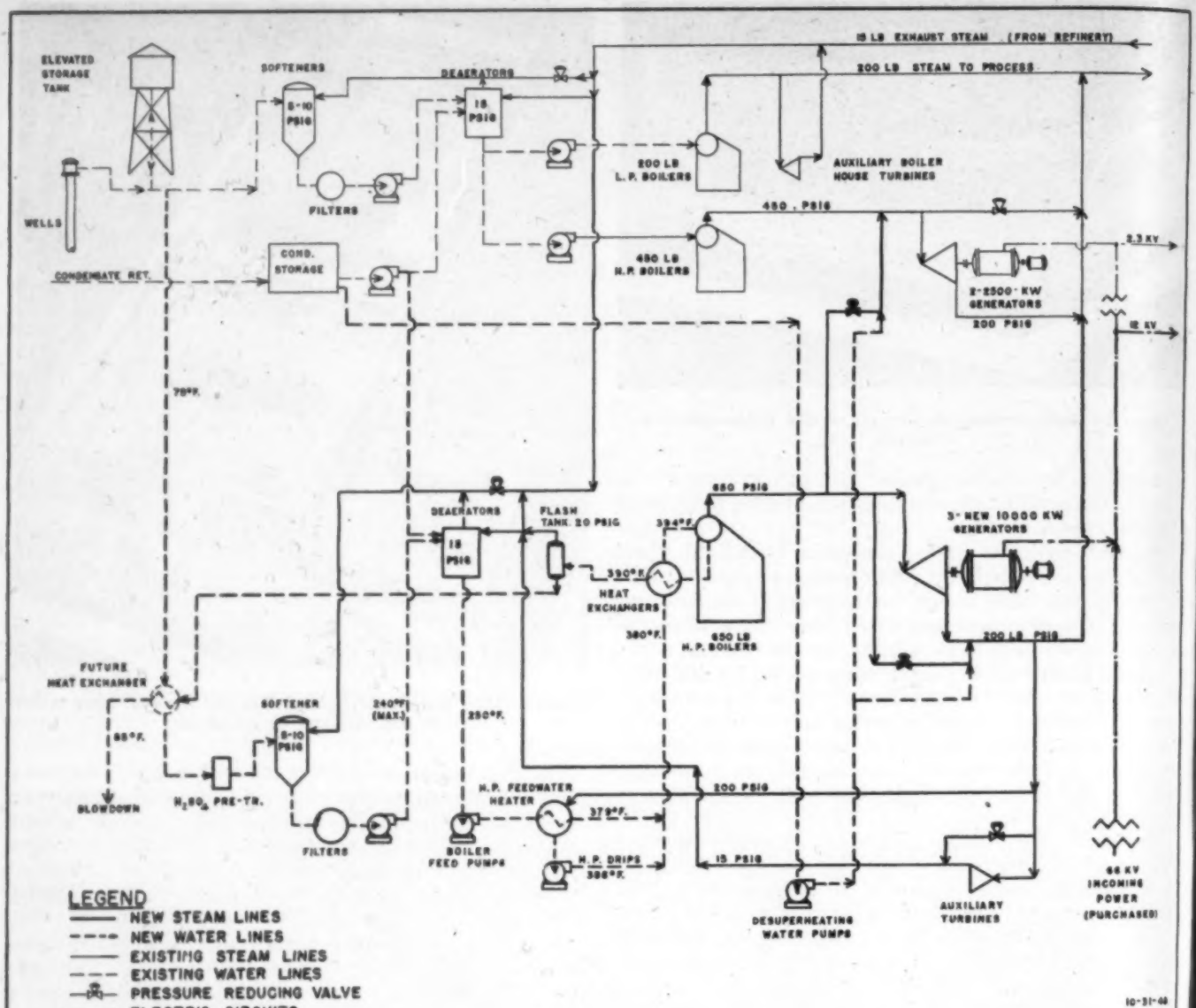

Figure 4—Simplified flow diagram of power plant extensions. Existing facilities are shown on the upper part of diagram and the new additions in heavier lines on the lower part.

low-pressure exhaust system which gathers steam at 15 psig from auxiliary power plant turbines and steam-driven refinery equipment. Provisions are made for injecting phosphate in the storage compartment of the softeners or direct to boiler drums. This method of treatment has replaced the hot lime-gypsum process with a resulting decrease of about 50 percent in the cost of chemicals. Treated feedwater and condensate are deaerated before being pumped through two closed stage heaters.

The first closed heater, shown in Figure 4 as the high-pressure heater, uses 200 psig steam from the main turbine exhaust as heat medium and the condensate or high-pressure drips are returned as boiler feedwater. This stage heater permits an increase in electric power generation of about 19 percent over and above that which can be generated with steam supplied to process and auxiliary turbines. The additional electric power is generated at a net thermal efficiency of 73 percent (95 percent for non-condensing turbine-generator multiplied by 80 percent net boiler efficiency and further reduced by 3 percent to allow for radiation). This is almost three times the thermal efficiency that would be attained by a condensing turbine installation. The flow follows a circular pattern from boilers through generator turbines and stage heaters and then back to the boilers.

The second closed heater, or high-pressure continuous-blowdown heat exchanger, conserves heat at a high temperature level.

Next in the line of flow in Figure 4, are the new high-pressure boilers. The economic pressure and temperature for steam generation were found to be 650 psig and 750° F. Process steam requirements are not quite large enough for the generation of all electric power loads with superimposed turbine and these initial steam conditions. Higher throttle pressures and temperatures, however, would involve appreciable initial investment for equipment, water conditioning and piping for which there is no economic justification with loads as projected.

During normal operation, practically all of the steam from the high-pressure boilers flows to the turbine-generators and is exhausted at 200 psig to the process steam headers. Only a relatively small amount flows through the pressure reducing valves which by-pass the main turbines. The by-pass arrangement not only permits the generators to take

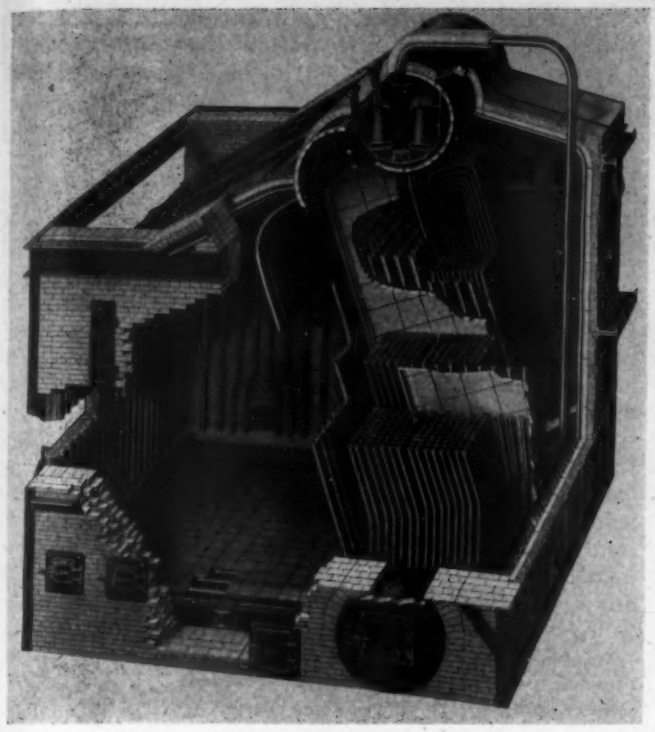

Figure 5—Cut-away view of new 250,000-pounds-per-hour integral furnace boilers.

load variations but also assures a steady supply of steam to the processes during either emergency as planned generator outages. The temperature of steam to process is controlled by injecting condensate on the downstream side of the pressure reducing valve for desuperheating.

Power plant auxiliary turbines are designed to take steam at 200 psig and to exhaust at 15 psig. The steam for these auxiliaries is efficiently used in that it is generated at 650 psig, expanded through the main turbines, further expanded through the auxiliary turbines; then it supplies heat to, and is condensed in, the feedwater softener and deaerator; and finally the condensate is returned with the feedwater to the boilers.

Electric Power Generation

The main advantage of superimposed turbine-generators, in refineries which use large amounts of process steam, may be demonstrated by comparing the heat requirements of such an installation with those of the conventional condensing turbine-generator of approximately the same size (10,000 KW) and initial steam conditions (630-650 psig at 750° F.). For example, the superimposed turbine-generator will take about 3610 Btu per KWH from steam on its way to process; whereas, the condensing installation requires 12,000 to 13,000 Btu per KWH of which some 70 percent comprises heat losses in the condenser. Thus, the net efficiency of electric power generation with steam subsequently used by processes and auxiliary turbines is 94.5 percent. As explained before, some 19 percent additional steam is used for stage heating of boiler feedwater. This steam is "skimmed" to generate electric power at a net efficiency of 73 percent. The estimated overall efficiency of electric power generation is 92 percent.

The throttle flow to the main turbines, under design conditions, is 36 pounds of steam per KWH of electric power generated. This does not mean, however, that the processes will utilize 36 pounds per KWH. Steam to auxiliary turbines and feedwater stage-heaters will tend to reduce the ratio; whereas, by-passing steam around the main turbines for control purposes, fouling, and under- or overloading the turbine-generators will tend to increase it. A ratio of 30 to 32 pounds of steam to processes per KWH is estimated for varying loads and conditions.

The use of non-condensing turbines superimposes efficient electric power generation on the refinery's processes which in themselves are efficient consumers of heat from steam. This may be demonstrated by a brief description of the process. About 25 percent of the total process steam goes to closed coils and heat exchangers in which the residual superheat and all the latent heat are transferred to process. The condensate is returned to the power plant. The remainder is divided among steam drives, stripping operations and miscellaneous uses. Steam supplied to drives for pumps, compressors, fans, etc., is admitted at 175 to 200 psig and exhausted to a 15 psig collecting system (except for a few outlying units which exhaust to atmosphere).

This low-pressure system supplies heat to closed coils, heat exchangers and to the water softeners and deaerators. Where steam is used in direct contact with petroleum fractions or chemicals for stripping operations, the available heat is efficiently used but the condensate generally is contaminated and cannot be economically returned and treated for boiler feedwater.

Turbine-Generators

The three main turbines are of the superimposed or non-condensing type, designed to generate power by reducing the pressure and superheat of high-pressure steam. They are impulse-reaction units with solid forged spindles, grooved for the direct setting of individually milled 13-chrome steel blades.

The generators are 3-phase, 60-cycle, 12,000-volt units designed for 10,000 KW each at 0.8 power factor, or 12,500 KW at unity power factor, but with maximum efficiency at 10,000 KW. Each generator is provided with a 250-volt, 50-KW direct connected exciter. The generator rotors, exciter rotors, and turbine spindles are each carried in two pressure lubricated bearings.

Each turbine is provided with a speed and back pressure regulating system which maintains generator synchronous speed as well as constant pressure in supplying process steam from the turbine exhaust. Maximum load protection is provided in each generator output circuit to protect the generator. Each of these devices is a contact-making watt meter which operates the turbine synchronizing motor and thereby lowers the load whenever the generator output reaches a set maximum. The reduction of generator output will not curtail the supply to process because electric power is purchased to meet peaks and other supplemental requirements, nor will decreases in steam from main turbine exhausts curtail the supply of 200-psig steam to process because automatic regulators and desuperheaters are provided in steam by-passes and adequate boiler capacity is available.

Additions or modifications to the standard accessories provided for the turbine-generators are: Fire protection equipment of the carbon dioxide type to serve all units, space heaters in the closed air cooling system to prevent damage to generators by condensation of acidic moisture during shutdowns, twin oil coolers which permit cleaning of one while the other

is in operation, fans and filters to draw cooling air through the exciters from the basement, incidentally ventilating the basement, and duplex low pressure gauges across the last rows of turbine blades to indicate the possible build-up of deposits on these blades.

The five new boilers each have a rated capacity of 250,000 pounds per hour steam at 650 psig. and 750° F. with feedwater at 380° to 394° F. Furnaces are completely water cooled and are designed for a maximum heat release of 26,100 Btu per cubic foot per hour with gas fuel and 24,600 Btu per cubic foot per hour with Bunker C fuel oil. Steam drums are 60 inches in diameter by 38 feet, 10 inches long and are equipped with cyclone steam separators and scrubbers to give a steam quality having maximum solids of 1 ppm. The superheaters are the bent tube, self-draining type built into the first boiler pass. A cut-away view of the boiler is shown in Figure 5. The boilers are steel cased and waterproofed for outdoor installation with enclosed firing aisle and pump and control room. The first of these units while under construction is shown in Figure 6.

Each boiler is equipped with forced and induced draft fans on a single shaft driven by a geared turbine. Shafts are extended for dual drive with future motors. Other boiler auxiliaries include combustion control with three element feedwater regulation, air preheaters with washers, and combination gas and steam atomizing oil burners. The principal fuel is a mixture of natural and refinery gases. Bunker C and other fuel oils are used for stand-by.

Steam plant auxiliaries include two new 640,000-pound-per-hour hot process lime softeners together with filters and deaerators, flash tanks and closed type tube and shell heat exchangers. A hopper will be provided for storing lime in carload lots. The lime will be fed automatically from the hopper to the softeners through gravimetric feeders equipped with slakers and controls.

Since part of the condensate returned from the process contains oil from reciprocating equipment, facilities are installed for oil removal. These consist principally of tanks, pumps and vessels in which the condensate is mixed with alum as a coagulant and then filtered through an anthracite bed.

Multistage double-suction centrifugal pumps with 1½ percent nickel cast iron cases and bronze impellers feed treated water to the boilers. Each pump has sufficient capacity to supply a single boiler, however, a total of eight such pumps will be installed for the five boilers. Four will be driven by motors and four by steam turbines which will exhaust into the low-pressure (15 psig) steam header. Thus, by the selection of pump drives, control can be maintained on the amount of low-pressure steam produced for heating and deaerating feedwater. Since varying amounts of low-pressure steam are returned from the refinery to the power plant, such control enables the power plant operator to better balance the steam-electric systems and avoid excessive loss of low-pressure steam to the atmosphere. Each turbine-driven feedwater pump is equipped with controls for automatic start-up in event of motor outages or low feedwater pressure.

The first of the five new 250,000-pounds-per-hour boilers and half of the water treating plant extensions have been in successful operation since September, 1946. The balance of the plant is scheduled for completion in progressive stages during 1947 and 1948.

Figure 6—One of the five new high-pressure boilers, shown while under construction. These 250,000-pounds-per-hour units help generate electricity as well as furnish steam for the refinery and chemical plants.

Application of Viscosity Measurement in Petroleum Refining Operations

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THE application of viscosity measurements to the control of petroleum refining operation as applied to lubricating oils, fuel oils, diesel fuels, jet fuels and various types of cut back asphalt is discussed here by the author. Places where automatic recording and control instruments for continuous measurement of viscosity would aid in the control of refinery processes making for more efficient operation are also indicated.

This paper was read at the September meeting of the Instrument Society of America.

IN THE refining of products derived from petroleum one of the important properties requiring close control is the measurement of viscosity of the materials to meet specification. Specificially this measurement applies to such liquids as lubricating oils, fuel oils, diesel fuels, jet fuels, hydraulic oils, certain types of greases, and various types of cut back asphalts used for road construction. Viscosity measurement is a very significant factor also in connection with other operations in the winning and handling of petroleum. In the drilling for oil the viscosity of drilling muds is important in determining the performance of circulating fluid in rotary drilling operations; in the pumping of crude oil from the well and also in the transportation by pipe line of the crude, viscosity plays an important role in the efficiency with which the oil is obtained from the ground and the ease with which it can be pumped to its destination for refining operations. The latter is of interest when it is considered that crude oil pipe lines extend for many hundreds of miles with pumping stations dispersed every 40 to 60 miles requiring considerable expenditure of energy in the pumping operations.

The viscosity of lubricating oil is a determining factor in reducing friction and therefore maintaining moving parts at safe operating temperatures. In the case of fuel oil and diesel oil whether these are used for heating or for power generation the ease with which the oil can be pumped is a criterion of its usefulness for a particular application. Hydraulic oil as used on airplanes must operate at extremes of temperature and for this reason it is important that such oil have good flowing characteristics at low temperature.

The viscosity of a fluid is defined as that property which is due to internal resistance offered to the motion of any portion of that fluid with a velocity different from that of a contiguous portion. It determines the resistance to shear, such as, to slow stirring and to flow through a capillary. The absolute dynamic viscosity (η) of a fluid is the tangential force on unit area of either of two parallel planes at unit distance apart when the space between the planes is filled with the fluid in question and one of the planes moves with unit velocity in its own plane relative to that of the other. The viscosity is expressed in dyne-seconds per square centimeter and has the dimensions, ($ml^{-1}t^{-1}$) in the centimeters-grams-seconds system. The absolute kinematic viscosity (ν) is equal to the quotient of absolute dynamic viscosity by the density of the fluid.

The unit for the dynamic viscosity (η) is the poise (p) and for kinematic viscosity the stoke (s). The derived units are the centipoise and centistoke.

$$1 \text{ cp} = 0.01 \text{ p}$$
$$1 \text{ cs} = 0.01 \text{ s}$$

Thus the kinematic viscosity in stokes

$$= \frac{\text{dynamic viscosity (poises)}}{\text{density (g/cc)}}$$

Viscosity Index

Another important property of a lubricating oil is the viscosity index. This is an empirical number indicating the effect of change in temperature on the viscosity. A low viscosity index signifies a relatively large change in viscosity with temperature and vice versa. Thus in a lubricating oil for use in internal combustion engines a desired characteristic is that in cold weather the viscosity is not too high to assure ease in starting and to afford proper lubrication of

various parts. Conversely, in hot weather the oil should not be too thin or have too low a viscosity in order to obtain good engine performance.

The viscosity index[1] ASTM Method D 567 can be calculated from the following formula:

$$VI = \frac{L - U}{L - H} \times 100$$

where U = Viscosity at 100° F. of the oil whose viscosity index is to be calculated.

L = Viscosity at 100° F. of an oil of 0-viscosity index having the same viscosity at 210° F. as the oil being measured.

H = Viscosity at 100° F. of an oil of 100-viscosity index having the same viscosity at 210° F. as the oil being measured.

Determination of Viscosity in the Laboratory

In a typical refinery control laboratory investigation has shown that approximately 300 determinations of viscosity are made per day (24 hours) in order to control the quality of the various products and to see that specifications are met. The bulk of the determinations, about 90 percent, are made on lubricating oils and the remainder 10 percent on asphalts, fuel oils and on diesel oils to a lesser degree. From this it is clear that considerable effort and time are spent on this determination alone and does not include other necessary tests, such as flash point, pour point, color and gravity of the various products to meet specifications. Kinematic viscosities are usually determined in the laboratory on lubricating oils and dark oils at temperatures of 100° F., 130° F., and 210° F. using the capillary type instruments; while for the determination of the viscosity of asphaltic type materials where extreme accuracy is not too important the Saybolt type of instrument is used at temperatures of 77, 122, 140 and 180° F.

Effect of Temperature on Viscosity

The accurate control of temperature is an important factor to be considered in the measurement of viscosity. This is true regardless of the type of instrument used; whether it is of the capillary type for kinematic viscosity work, or of the Saybolt type. The effect of temperature on viscosities of various types of oils is illustrated in the data of Table 1 of Cannon and Heidrich[2] which is reproduced below for the reader's convenience:

TABLE 1

Effect of Temperature on Viscosity

Oil	Viscosity in Centistokes at				Average Percent Change in Viscosity per °F. Change in Temperature	
	210° F.	180° F.	100° F.	80° F.	100–80	210–180
A	4.36	6.16	24.95	41.9	3.4	1.38
B	4.36	6.48	34.08	64.9	4.5	1.62
C	15.8	25.68	176.3	365.0	5.4	2.1
D	15.8	29.12	362.0	957.0	8.2	2.8

From the above data it is seen that to obtain an accuracy of 1 percent in a viscosity measurement for oil A the temperature should be controlled to 0.3° F. in the range of 80-100° F. and to about 0.7° F. for the range of 180 to 210° F. In the case of oil D, however, temperature must be controlled much more closely (about 0.1 and 0.36° F.) to obtain 1 percent accuracy for the equivalent temperature range. The accuracy obtainable by the kinematic viscometer, according to the ASTM Method D 445, is of the order of 0.2 percent; but here the temperature should be controlled to at least 0.05° F. to meet the requirements of this test.

TABLE 2

Various Fractions Obtained from a Lubricating Oil Distillation Column

	S.U.S. at 100° F.	S.U.S. at 210° F.	Approximate Temp. °F.
Reflux Cut	67	...	370
Light Cut	246	...	410
Cut 1	...	60	490
Cut 2	...	114	495
Cut 3	...	225	500

Manufacture of Lubricating Oil

Crude oil as obtained from a well contains the lubricating oil which has to be separated and refined to be of use. The first step in the distillation of crude separates the various component fractions from the lighter to the heavier, such as gasoline, kerosine, fuel oil (gasoil), lubricating oil and the residue asphalt. The lubricating oil fraction is next vacuum distilled to obtain closer boiling components having definite ranges of viscosity.

In a typical refinery distilling of 15,000 barrels per day as many as five fractions are obtained as indicated in Table 2.

A side stream from the various cuts is diverted to a control house where an operator periodically checks the viscosity with a Saybolt instrument. At this point the measurement of viscosity is an aid to the operator in properly controlling the column. The control laboratory rechecks the samples as obtained from storage tanks before the oil is pumped to the next stage of the refining process.

The lubricating oil fractions so obtained are not suitable as quality lubricants because they contain undesirable components (unsaturated compounds, resins, aromatics and asphalt formers) which produce an oil having a wide variation in viscosity with changes in temperature. One of the methods which is extensively used for removing these undesirable components is solvent refining, with furfural[3] as the extraction agent. Such extraction results in an oil having good viscosity-temperature relationships which permits of easy starting of an engine at low winter temperatures. Since the plant is operated so as to produce an oil of a certain viscosity index, control of the extraction process is accomplished by sending samples to the laboratory and the viscosity is measured at two temperatures (100 and 210° F.) from which the viscosity index is calculated. In this connection it may be mentioned that a measurement of refractive index[4] of the treated oil can be correlated to the viscosity index. However, the measurement depends on the type of crude being processed; thus a change in the crude requires a different value of refractive index to obtain correlation with viscosity index. While refractive-index measurement is an indirect means for determining viscosity index, its measurement has a distinct advantage for plant control, the reason being that the test can be made with an Abbé refractometer by the operator and if necessary corrective measures applied without the need of obtaining laboratory results. The latter procedure is time consuming, especially when the viscosities at two temperatures need to be measured to calculate viscosity index.

Where paraffinic crudes are involved the solvent-

refined oil contains sufficient wax to make it unsuitable for use over a wide temperature range and this must be removed so that the oil will flow freely at low temperatures. In this case the viscosity of oil as well as its pour point is measured as a means of controlling the dewaxing process.

Blending Refinery Stocks

A number of refinery operations require the blending of various lubricating stocks to viscosity and viscosity index specifications. For example, a light or neutral stock may be blended with a heavy or bright stock to yield a particular grade of motor oil. Blending is done by mixing two or more oils in either kettles, tanks, bleachers, or homogenizers which, with the exception of the latter, are equipped with steam coils for heating, and either air or mechanical mixers for stirring. It is necessary for the control laboratory to determine the viscosity or viscosity index of the blends to insure proper quality before the material is pumped to drums, cars or storage. In these operations considerable thought is being given to automatic blending devices and means for continuous determination of viscosity as this will reduce the need for expensive storage capacity, aid in better control of the process and decrease labor costs of analysis.

Similarly it is necessary to blend fuel oil and road oils. A specific example is in the blending of a fuel oil of 800 to 1200 seconds viscosity (Furol at 122° F.) with a lighter fraction to yield a product of 125 seconds viscosity for storage. Blending by means of gravity measurements is not a satisfactory means of control because the viscosity of the material is a limiting factor in meeting specifications.

Need for Continuous Recording Viscometers

In the above discussion it will be noted that no mention is made of either direct indicating or recording viscometer instruments for the automatic control of processes. At the present time, except in a few isolated cases,[5] such instruments which can be satisfactorily used in a refinery are practically nonexistent. The impetus given to the development of specialized instruments in the past few years will no doubt change this condition because of the need for improving quality of products and decreasing operating costs. It is well recognized that one way of attaining this objective is the adaptation of automatic-control instruments to the control of a process.

The places where automatic instruments would be useful to the control of process variables are briefly summarized:

(1) At the control house where the lubricating oil fractions are obtained. At this point an accuracy of 1 to 2 percent in a determination is probably sufficient for the purpose because the oil requires further processing.

(2) At solvent refining and dewaxing plants. In this case the measurement of viscosity index is important and the viscosity must be measured quite accurately in order to obtain a good value for the index. Indirect methods, such as continuous measurement of refractive index, may be used to obtain a measure of viscosity index.

(3) At the compound house where the lubricating oil is blended. Especially would this be important if continuous blending operations were developed because viscosity measurement would be required soon after the mixing took place.

(4) At pump houses where road oils are blended and asphalts are pumped to tank cars, trucks or barges.

From the above considerations it is plain that much work remains to be done in the development of specialized instruments for indicating or recording of viscosity and viscosity index to obtain more efficient control of refinery processes. A knowledge of the process, the variables to be encountered and the accuracies to be achieved in the measurement is essential to produce a workable instrument.

Acknowledgement

Appreciation is expressed to Shell Oil Company, Incorporated, for permission to use information regarding certain of their refinery operations and to Messrs. J. G. Kerley and E. F. Tesche for helpful discussions.

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[5] The Fischer and Porter Company, Hatboro, Pa., market a continuous recording viscometer which may have applications to certain refinery operations.

Pilot-Plant Evaluation Of Fluid Cracking Catalysts

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VARIOUS laboratory methods for the evaluation of fresh fluid cracking catalysts are used in the Universal Oil Products research and development laboratories for the testing of samples of new catalysts prepared in the course of research studies, as well as for comparing the properties of quality control samples representing commercial production lots of cracking catalyst. Such tests are useful in connection with the latter group of samples, which are made by standardized techniques, and for which an adequate background of commercial catalytic cracking experience is available for interpretation of the laboratory test results. It has been found, however, that the available laboratory evaluation tests are sometimes inadequate for testing new catalysts because of the lack of similarity in process conditions between laboratory and commercial units. These tests are occasionally misleading because carbon yield, which is of prime importance in evaluating new catalysts for commercial use, is difficult to measure accurately. In some instances it has been found that full-scale pilot-plant testing is advisable for precise evaluation of the potential utility of new catalysts.

By operating complete pilot-plant catalytic cracking units under process conditions parallel to those that exist in the full-scale catalytic cracking units, reliable comparative data can be obtained which can be used with confidence for making economic studies in connection with commercial application of a new catalyst. The reliability of pilot-plant data for predicting commercial results has been demonstrated by a number of comparative runs which have indicated good agreement in the results of the commercial and the pilot-plant units.

This paper was presented at a Division of Refining Symposium, American Petroleum Institute, annual meeting in Chicago early this month.

A NUMBER of laboratory methods for the routine evaluation of fluid cracking catalysts are in use in the research and development laboratories of the Universal Oil Products Company. These methods are used to evaluate fresh catalyst samples as well as samples that have seen service in either pilot-plant or commercial fluid catalytic cracking units. The tests as applied to fresh catalyst can be divided into two rather arbitrary categories, viz., those intended to evaluate the catalyst as produced, and those intended to give indications of the behavior of the catalyst after some aging. Typical of tests in the first category are the determination of catalyst activity as measured by the hydrocarbon conversion observed in a fixed-bed testing unit at given processing conditions, and certain physical property determinations such as apparent bulk density, specific surface area,[1] mean pore diameter,[1] and particle-size distribution[2] obtained either by screen or by sedimentation analyses. Tests on the fresh catalyst falling into the second category are not so extensively used, but these include catalyst-activity tests made on samples subjected to accelerated thermal and steam treatments in order to test catalytic stability, and attrition tests intended to test mechanical stability.

Utility of Laboratory Tests

The laboratory tests are quite useful in exercising quality control over commercial production of fluid cracking catalyst, because such material is made by standardized techniques, and an adequate background of commercial catalytic cracking experience is avail-

TABLE 1
Laboratory Catalyst Evaluation Data

	CATALYST SAMPLE NO.				
	1	2	3	4	5
Physical properties—					
Apparent bulk density, square meters	0.48	0.69	0.45	0.59	0.35
Specific surface area, per gram	462	336	697	616	266
Mean pore diameter λ	53	53	39	53	141
Average particle size μ	186	78	139	91	232
Laboratory fixed-bed activity evaluation					
UOP weight-activity rating	52	50	90	59	42
Carbon, estimated at 50 percent conversion	0.52	0.77	1.08	2.62	0.74

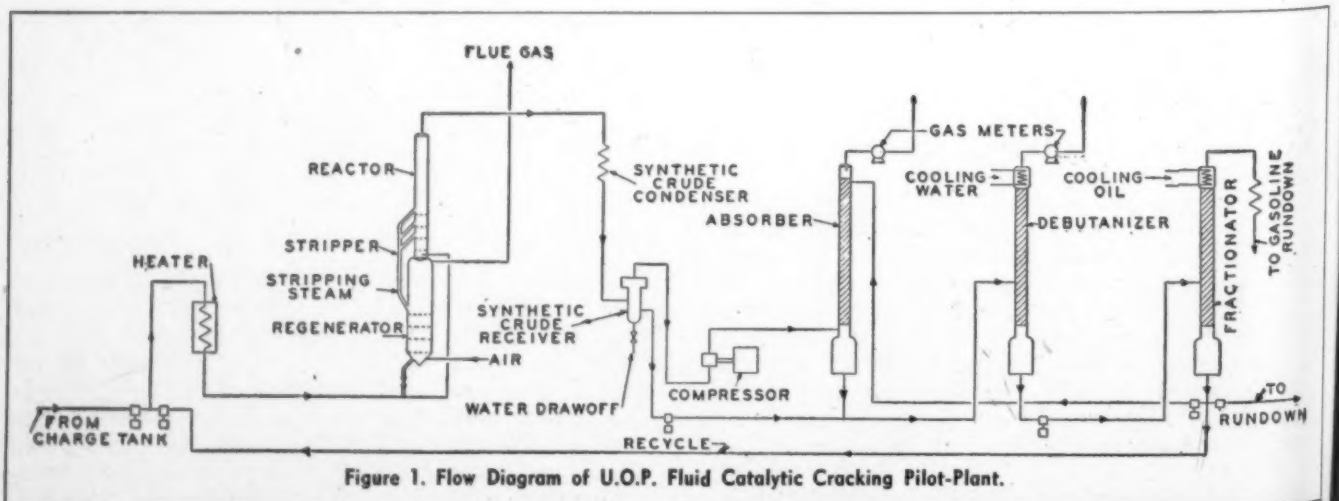

Figure 1. Flow Diagram of U.O.P. Fluid Catalytic Cracking Pilot-Plant.

able for interpretation of the test results. These tests are also useful for the inspection of used catalyst samples from commercial units. For example, the slope of the "catalyst-activity vs. service-time curve" is a measure of the catalyst deactivation rate; and, if no makeup catalyst were added to the unit, the extrapolation of this line to what would be considered a minimum operable activity would indicate the useful catalyst life. However, in investigating the causes of unusual degradation of catalysts from certain commercial units, the standard laboratory activity tests are of less utility, and the inspection of such samples frequently becomes a research task utilizing special techniques of analysis such as X-ray-diffraction and emission-spectroscopy studies.

Although the physical tests are of interest and utility in the evaluation of new catalysts prepared in the course of research studies, the methods of testing catalyst activity by means of fixed-bed operations have been found to be primarily useful as a simple means of eliminating inferior materials. These catalytic tests can be modified to obtain information other than the activity alone, such as, for example, the determination of carbon- and gas-producing factors. The factors obtained in such modified tests give incomplete data in regard to the product distribution; i.e., the distribution of converted material to gas, gasoline, and coke. A reasonable explanation for this is that the process conditions for fluid and fixed-bed processing are quite different in that the single-process-cycle fixed-bed activity tests generally operate at low conversions over a long process period and to high carbon contents of the spent catalyst—which are in contrast to the high conversion, short catalyst-holding time (fluid analogue of process-period length), and relatively low spent-catalyst carbon concentrations experienced in fluid operations.

It is probable, that in the future, laboratory tests will be even more useful in the testing of new catalysts, as modifications are being made to the existing fixed-bed activity tests to provide more reliable product distributions. It will also be necessary to accumulate parallel pilot-plant and laboratory data for correlation purposes. Such modifications will appreciably reduce the development expense in complete catalyst evaluation studies.

TABLE 2
Pilot-Plant Yield Data

	CATALYST SAMPLE NO.				
	1	2	3	4	5
Yields, percent by weight of charge—					
Hydrogen sulfide in process gas	0.3	0.3	0.3	0.3	0.3
Dry gas, C_3 and lighter	5.2	5.0	5.2	5.2	7.6
Butane-butylene fraction	9.0	10.4	9.0	9.6	12.6
Debutanized gasoline	40.7	39.6	33.9	38.7	34.0
Catalytic gasoil	40.9	40.9	40.9	40.9	40.9
Catalyst deposit	3.9	3.8	4.7	5.3	4.6
Yields, percent by volume of charge—					
(Dry gas, C_3 and lighter, cu ft per barrel of charge)	(198)	(158)	(204)	(244)	(259)
Butane-butylene fraction	13.3	15.4	13.3	14.2	18.6
Debutanized gasoline	47.5	46.1	46.5	45.1	39.6
Catalytic gasoil	40.0	40.0	40.0	40.0	40.0
Total liquid recovery	100.8	101.5	99.8	99.3	98.2
Yields after polymerization, percent by volume of charge—					
10-lb-RVP C_3C_4 polymer	6.4	7.7	7.1	7.0	10.8
10-lb-RVP catalytic gasoline	50.0	48.4	48.9	47.3	41.5
Total 10-lb-RVP gasoline	56.4	56.1	56.0	54.3	52.3
Excess spent butane-butylene fraction above 10 lb RVP	6.2	6.9	5.5	5.8	8.4
Total liquid recovery	102.6	103.0	101.5	100.1	100.7

At the present time, however, we feel that pilot-plant evaluation on a 3- to 4-barrel-per-day scale is usually desirable on all catalysts that appear promising by the available laboratory test procedures. For pilot-plant evaluation work, we use units such as that shown diagrammatically in Figure 1, the UOP fluid catalytic cracking pilot plant which has been described in some detail in past publications.[3] These units can be operated at process and regeneration conditions which leave few uncertainties in comparing pilot and commercial scales of operation. In addition, specification gaseous and liquid product streams are produced which improve the reliability of product-distribution data. Catalyst evaluation tests in such equipment are run on a standard charging stock, and the program usually consists of a series of three or four once-through tests covering a wide conversion range plus a similar series of two or three recycle tests. In general, all these tests are made at constant reactor temperatures, and with the catalyst-to-oil ratio being varied to maintain essentially a constant regenerator temperature. Reliability of such test results is satisfactory, with product recoveries averaging above 98.5 percent by weight of the feed stocks.

Laboratory data on five different fresh synthetic catalysts, each prepared by a different technique, are presented in Table 1.

These same five catalysts were evaluated in the pilot-plant, and the pilot-plant data at various conversion levels have been plotted to permit interpolation so that all catalysts could be compared at a constant conversion level of 60 percent, where conversion is expressed as 100 percent by volume of catalytic gas oil. The yield data at this common conversion level are shown in Table 2 (expressed as direct yields from the catalytic cracking operation) as calculated yields after polymerization of the available propylenes and butylenes, and after blending the polymer and debutanized catalytic gasoline to 10-pound Reid vapor

TABLE 3
Properties of Pilot-Plant Products

	CATALYST SAMPLE NO.				
	1	2	3	4	5
Dry gas, C_3 and lighter—					
Hydrogen, mole percent	22.5	5.6	25.3	21.5	14.1
Methane	5.3	8.3	4.6	26.9	5.2
Ethylene	6.6	6.0	6.4	8.0	6.6
Ethane	6.5	6.0	6.3	8.0	6.5
Propylene	45.2	56.7	43.9	27.2	53.1
Propane	13.9	17.4	13.5	8.4	14.5
Average molecular weight	30.2	36.4	29.3	24.5	33.6
Butane-butylene fraction—					
Isobutane, percent by volume of liquid	8	7	8	10	14
Butene—1	10	5	11	11	10
Butene—2	17	29	22	24	23
Isobutane	52	47	47	44	42
Butane	13	12	12	11	11
Debutanized gasoline—					
Gravity, degrees API	58.5	58.5	58.5	58.5	58.5
Octane ratings—					
*F-1 method, without TEL addition	92.5	92.0	91.5	92.5	95.5
F-1 method, plus 3 ml TEL per gallon	97.0	98.0	97.5	98.0	99.5
†F-2 method, without TEL addition	81.0	81.0	81.0	81.5	82.5
F-2 method, plus 3 ml TEL per gallon	86.5	86.5	86.5	87.0	87.0
ASTM distillation, degrees F.—					
Initial boiling point	107	107	105	103	100
10 percent point	137	134	137	127	126
57-percent point	217	206	214	204	197
90-percent point	362	368	364	360	360
End point	409	414	407	414	404
Catalytic gasoil—					
Gravity, degrees F	28.0	28.0	28.0	28.0	28.0
ASTM distillation degrees F—					
Initial boiling point	488	488	488	474	486
10-percent point	510	512	511	499	511
50-percent point	566	560	572	562	572
90-percent point	673	656	685	677	679

* F-1 = Research Method. † F-2 = Motor Method.

pressure with the available residual butanes. It can be seen that catalysts 1, 2, and 3 give very similar results, except that the total liquid recovery from operations with catalyst 3 is about 1.0 to 1.5 percent less than with catalyst 1 or 2. Catalysts 4 and 5 produce decidedly less gasoline, either debutanized catalytic or blended 10-pound RVP catalytic and polymer, than do the other 3 materials. It is apparent that the laboratory carbon gives a fair indication as to whether a catalyst is a high or a low coke producer, but it is unreliable in predicting the magnitude of the differences in coke production between catalysts.

Table 3 presents detailed product inspection data which are not obtainable from standard laboratory evaluation tests. The standard single-cycle tests can be readily modified to determine gas compositions, but these would be at very low conversions and, hence, of different composition than would be obtained in high conversion operations. Quantities of liquid products from laboratory tests are not usually adequate for determination of gasoline and product gas-oil properties. In comparing this group of catalysts, attention should be drawn to the high-density dry gas produced by catalyst 2, which reduces the plant investment required in gas-concentration and -separation equipment. This advantage for catalyst 2 might be sufficient to offset the slight advantage in gasoline yields that catalyst 1 shows in Table 2. Catalyst 4 produces large volumes of hydrogen and methane; and, although the octane ratings of the gasolines produced over this catalyst are slightly higher, this is probably not enough to justify its use. Catalyst 5, although giving very poor gasoline yields, produces large quantities of olefins in the dry gas and in the butane-butylene fraction, so that it might be of utility in some rather specialized refinery application where such gaseous olefins are of premium economic value. In addition, the gasoline produced over catalyst 5 is of unusually high F-1 (Research) method octane ratings.

It is evident from the data in Tables 2 and 3 that sufficient information is obtained to evaluate the catalyst reliably as to its commercial possibilities.

Comparison of Pilot-Plant and Commercial Unit

In the past a number of sets of data comparing pilot-plant and commercial operations have been accumulated, indicating agreement between the two types of units. As these data were mostly concerned with aviation-gasoline production, there are presented in Tables 4 and 5 recent data pertaining to pilot-plant and commercial operations on the same charging stock while producing motor fuel. The catalyst and feed stock used in both scales of operation were the same; because, at the conclusion of the commercial test run, a catalyst sample was withdrawn from the large unit and transferred to the pilot plant, and charging stock from the commercial unit was used in the pilot-plant runs. The data of Table 4 give the properties of the oil processed in both units.

The yield and product-quality data compared in Table 5 indicate satisfactory agreement between the two scales of operation. The only appreciable difference in product distribution is in the catalyst-deposit yield, where the pilot plant shows a lower coke production— which is perhaps due to somewhat better stripping in the pilot-plant equipment. The commercial gasoline shows slightly lower octane ratings than does the corresponding pilot-plant product. These octane differences are probably due to difference in fractionation between the two scales of operation, as well as to the fact that, in the commercial operation, some slurry oil was returned to the reactor from the base of the fractionator. This resulted in a partial recycle operation and, thus, an accompanying reduction in octane number.

TABLE 4

Properties of Feed Stock

Gravity, degrees API	30.6
Sulfur, percent by weight	0.54
Aniline point, degrees F	185
Cold test, degrees F	75
Conradson carbon, percent	0.19
Characterization factor	12.0
100-ml distillation, degrees F:	
Initial boiling point (corrected to atmospheric pressure)	480
5-percent point	570
10-percent point	606
30-percent point	664
50-percent point	709
70-percent point	762
90-percent point	869
95-percent point	912

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[2] G. M. Webb, Petroleum Processing 2 [7] 497-502 (1947).
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TABLE 5

Comparison of Pilot-Plant and Commercial Results

	Pilot	Commercial
Volumetric combined feed ratio	1.0	1.2
Yield data—		
Hydrogen sulfide in process gas, percent by weight of charge	0.3	0.3
Dry gas, C_3 and lighter, percent by weight of charge	4.1	4.1
Butane-butylene fraction, percent by volume of charge	11.1	10.7
Debutanized gasoline, percent by volume of charge	41.0	40.7
Catalytic gasoil, percent by volume of charge	48.5	48.5
Catalyst deposit, percent by weight of charge	4.3	5.1
Total liquid recovery, percent by volume of charge	100.6	99.9
Properties of products—		
Dry gas, C_3 and lighter	....	....
Hydrogen, mole percent	42.0	31.4
Methane, mole percent	12.8	13.4
Ethylene, mole percent	3.2	4.6
Ethane, mole percent	5.1	8.5
Propylene, mole percent	24.9	27.2
Propane, mole percent	12.0	14.9
Average molecular weight	21.1	24.6
Butane-butylene fraction—		
Total butenes, percent by volume of liquid	38	38
Isobutane	48	54
Butane	14	8
Debutanized gasoline—		
Gravity, degrees API	58.0	59.2
Octane ratings—		
F-1 method, without TEL addition	89.5†	89.5†
F-1 method, plus 3 ml TEL per gallon	96.0†	95.5†
F-2 method, without TEL addition	79.5†	78.0†
F-2 method, plus 3 ml TEL per gallon	85.5†	85.0†
ASTM distillation, degrees F.—		
Initial boiling point	108	107
5-percent point	132	122
10-percent point	139	130
30-percent point	170	166
50-percent point	222	217
70-percent point	293	277
90-percent point	363	354
95-percent point	385	381
End point	403	432

	CATALYTIC GASOIL		
	Total	Light*	Heavy*
Gravity, degrees API	28.5	31.8	26.7
ASTM distillation, degrees F.—			
Initial boiling point	494	396	520
10-percent point	520	448	595
50-percent point	594	516	657
90-percent point	695	596	746
End point	760+	655	760+

* 60 percent of total catalytic gasoil is light fuel oil.
† Gasolines as analyzed contained approximately 3.9 percent straight-run naphtha from feed stock.

Investigation of a Girbotol Unit Charging Cracked Refinery Gases Containing Organic Acids

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THIS paper describes a laboratory investigation to determine the cause and method for preventing the contamination of the diethanolamine solution used in the H_2S gas purifying system of a thermal polymerization unit.

The investigation identified the inactivating agents to be formic and acetic acids. Inasmuch as both acids are infinitely soluble in water a simple pre-water wash removed these acids before they had a chance to react with the diethanolamine. As formic acid is considered the most corrosive of the fatty acid series, a pre-wash of an aqueous caustic solution was necessary to neutralize the corrosive action, which was especially severe at the temperature and pressure employed in the system.

When the diethanolamine is protected from organic acids, satisfactory operation of the scrubbers in the removal of hydrogen-sulfide and the decrease in the consumption of diethanolamine is achieved.

This paper was presented at a meeting of the American Chemical Society in Dallas.

SINCE its installation before the war the diethanolamine (DEA) H_2S gas purifying system of The Pure Oil Company's Smith's Bluff refinery thermal polymerization unit has consumed excessive amounts of DEA. This system, employing the Girbotol process, is used to remove hydrogen sulfide from cracked refinery gases which are polymerized to motor gasoline. During the war thermal polymerization was discontinued in order to utilize the C_4 gases for Alkylation and feed stock to the Neches butane rubber pool. The gas purifying and absorption sections were converted to a B-B preparation plant and the polymerization section was converted to a reforming unit. However, when the change was made, the DEA consumption progressed from bad to worse; presumably due to the deeper C_4 cut being made. Also it became practically impossible to sweeten the gas for more than a few hours at a time even with a fresh charge of DEA.

The gases charged to the DEA scrubbers are the gas streams from the thermally cracked gasoline stabilizer feed (SFA) and reflux (SRA) accumulators. These gases are under different pressure, hence they are scrubbed in separate towers with a 5 to 10 percent DEA solution for removal of hydrogen sulfide. The purified gases go to the absorption section while the spent DEA is regenerated by boiling off H_2S in the reactivator tower. (See Figure 1.)

TABLE 1

Tabulation showing gradual decrease in free DEA content after the system was cleaned and a fresh DEA charge made

DEA Charge = 4 drums @ 500 lbs./drum = 2,000 lbs.
Approx. Capy. system = 3,420 gal. = 28,500 lbs.

$$\therefore \%\ \text{DEA} = \frac{2000 \times 100}{28{,}500} = 7.02\%\ \text{(on basis of charge)}$$

Average Gas Flow SFA — 5522 Mcf per day — 0.944 Sp. Gr.
SRA — 3404 Mcf per day — 1.557 Sp. Gr.

Laboratory Analyses of Regenerated DEA Samples (by titration).

DATE	Time	Vol. Percent Free DEA
4-2	1 P.M.	7.04
	5 P.M.	6.71
4-3	1 A.M.	4.95
	11 A.M.	3.08
	5 P.M.	2.97
4-4	1 A.M.	2.86
	9 A.M.	2.97
	5 P.M.	3.08
4-5	1 A.M.	2.97
	9 A.M.	2.64
	5 P.M.	2.97
4-6	1 A.M.	2.75
	5 A.M.	2.70

Diethanolamine has an alkaline reaction at normal temperatures (below 160°F.) and hence reacts with acidic compounds as do other alkalis. With acidic gases such as H_2S and CO_2 the resulting compound is so unstable that it can be decomposed on heating to boiling. The acid gas is flashed off and the diethanolamine is utilized in a continuous cycle. Thus:

$$R_2NH + H_2S \underset{\text{High Temp.}}{\overset{\text{Low Temp.}}{\rightleftharpoons}} R_2NH_2HS$$

DEA — Hydrogen Sulfide — DEA Hydrosulfide

However, the reaction with mineral acids or more stable organic acids give stable salts which are not decomposed at the temperatures of operation.

Additions Too Frequent

Theoretically, the DEA can be completely regenerated from the H_2S or CO_2 salt but mechanical losses and impurities in the gas stream make addi-

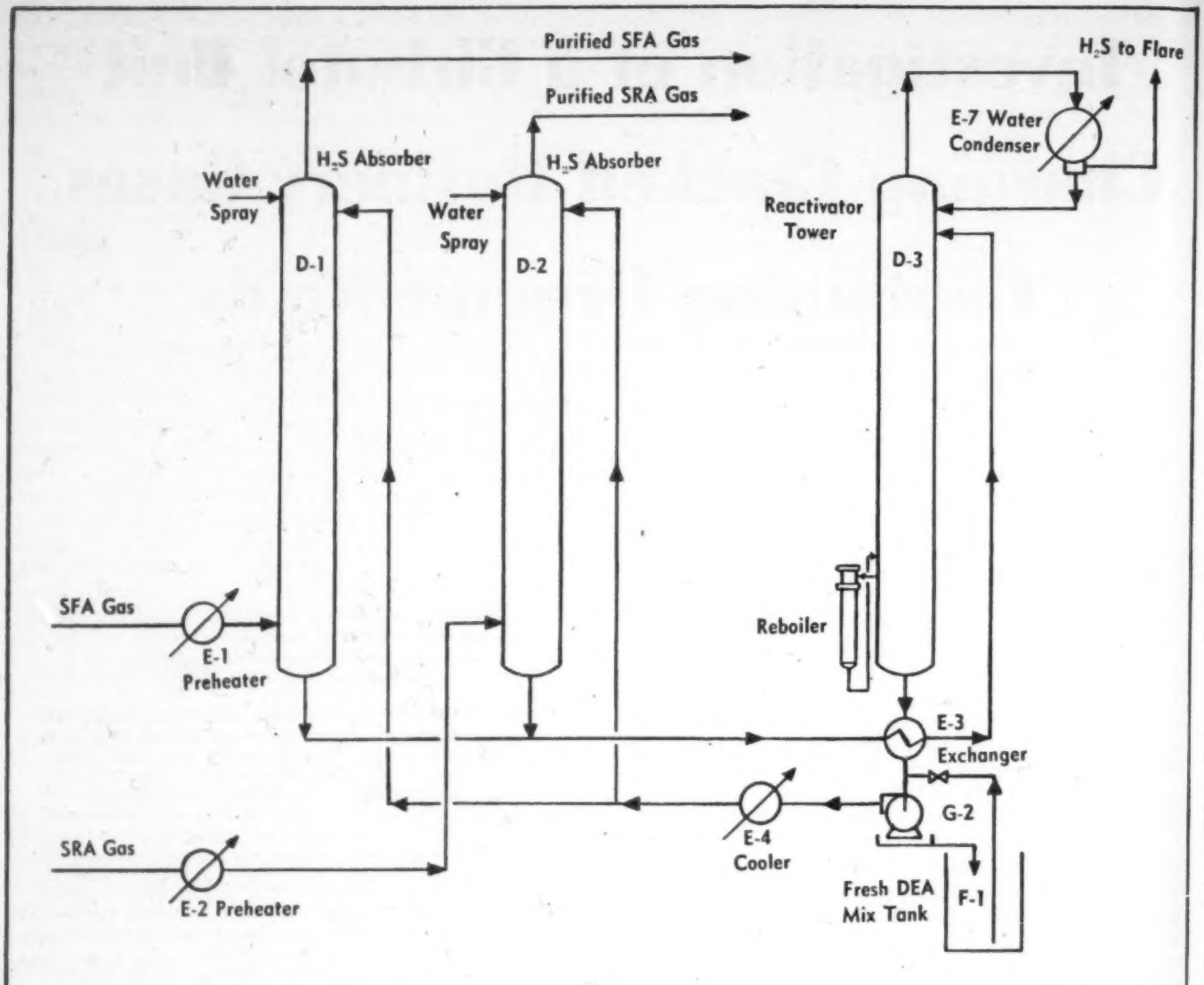

FIGURE 1. FLOW DIAGRAM OF GIRBOTOL UNIT

tion of fresh DEA necessary. At Smith's Bluff refinery these additions have been all too frequent. Mechanical losses are seemingly reduced to a minimum by returning to the system tower carry-over and pump leakage; hence the rapid consumption of DEA was thought in all probability to be due to impurities in the raw gases which react with the DEA to form stable compounds. Laboratory analyses confirmed this assumption. For example, at a time when the gas was not being sweetened, analysis of the regenerated DEA solution showed only 2.15 percent free or available DEA (when determined by Girdler's recommended titration to a methyl red end point), while it contained a total of 10.58 percent DEA calculated from the nitrogen content of the solution. There was no ammonia present in the solution. This means that 8.43 percent of the DEA had reacted with impurities in the gases to form stable compounds which could not be regenerated by boiling. Also a hydrogen sulfide balance on the DEA scrubbers at the same time showed no removal of H_2S in spite of the fact that the amine solution indicated 2.15 percent free DEA.

Attempts were made to release the combined DEA by the addition of caustic as recommended by Girdler but none was entirely successful and generally resulted in a lumpy black precipitate which fouled up the exchangers and made it necessary to dump the solution.

At this point a laboratory investigation was made to identify the material that was combining with the DEA, to determine why caustic additions were unsuccessful, and to develop a means for overcoming the trouble.

Analyses of the incoming gases and also of the spent amine solution showed the presence of acidic compounds other than H_2S and CO_2 in amounts which often exceeded 0.07 weight percent. This is enough acid to tie up effectively all the amine in the system in a day or so. Such was found to be the case in an actual plant test. For example, a fresh charge of 7.04 percent DEA was made. In 22 hours this had been reduced to 3.08 percent free DEA as determined by the methyl red titration method. The DEA content apparently became constant at approximately 3 percent free DEA and remained at this level for the duration of the test. (See Table 1.) Also, after the first 22 hours, there was little or no removal of H_2S from the gas. This prompted an investigation to determine the reliability of Girdler's titration procedure. A sample

of regenerated DEA, which by titration with sulfuric acid to the methyl red end point indicated 3.02 percent free DEA, was heated until all water was driven off. The remaining syrupy residue was extracted with acetone to remove free diethanolamine. The remaining material was extracted with methanol to remove the combined DEA from inorganic material. Examination of each of the extracts gave the following results when calculated back to the original sample:

	Weight Percent
Free DEA	0.96
Combined DEA	4.75

The titration method indicated 3.02 percent free DEA while actual analysis showed only 0.96 percent free DEA with 4.75 percent combined DEA.

Deceptive Result

From this it is evident that the usual methyl red titration for free DEA is not reliable in the presence of DEA organic acid salts. The solution of amine and amine salt is apparently buffered by the salt and the free amine is over titrated. Undoubtedly, the mineral acid used in the titration releases some of the organic acid in the DEA organic acid salt to also give a deceptive result.

An analysis of the combined DEA extract was made to identify the inactivating compounds.

A molecular weight determination on this material showed that the amine had not split up or polymerized.

A sample of the amine salt was dissolved in water and treated with an equivalent amount of sulfuric acid based on the nitrogen content. The solution was then distilled to remove organic acids displaced from the salt by sulfuric acid. The organic acids were trapped in water. The amine-sulfate mixture in the distillation flask was then treated with an equivalent amount of caustic to exactly neutralize the sulfuric acid previously added. The mixture in the flash was then further titrated for free DEA. The recovered organic acids were converted to the esters by refluxing with methanol and the methyl esters were separated by fractional distillation. These were identified by boiling point, freezing point, and refractive index as the formate and acetate. The free DEA calculated in the flask indicated that practically all of the combined DEA had been liberated.

From these results it was concluded that organic acids (principally formic and acetic) were the major DEA inactivating agents in the gases going to the Girbotol unit.

As the combined DEA had been successfully regenerated in the laboratory the reason was sought why this same result had not been accomplished in similar attempts in the plant. Analyses of black suspended material in the DEA solution showed this to be iron sulfide. As iron sulfide is practically insoluble in an alkaline solution this was not the answer to the problem although the iron sulfide did give trouble by discoloring the solution and fouling gauge glasses. Further investigation revealed the presence of a considerable amount of dissolved iron in the solution. It then was clear that in the attempted regenerations the caustic had reacted with the dissolved iron compounds and produced a heavy flocculent precipitate of iron hydroxide. This was the material which fouled up the exchangers and made it necessary to dump the solution.

Charged with Water

The inactivating agents in the feed gas had been convincingly identified as acetic and formic acids. As these two acids are infinitely soluble in water it was thought that a simple pre-water wash would remove these acids before they had a chance to react with the DEA. It was decided to try this on a plant scale, so the DEA scrubbers were washed out and then charged with water. The gases were then cut back into the towers and water scrubbed in a batch and also in a continuous process. In the latter, acidified water was replaced with fresh water at 5 gallons per minute. Samples of the wash water taken after equilibrium appeared to be established gave the following results:

	Batch	Continuous
pH	4.33	5.23
Free and Combined Acid as Acetic	2.77	0.08
Combined Iron as Fe	0.41	0.04

Both of these runs indicate the removal of organic acids by the water wash but also they both indicate excessive corrosion due to the low pH of the wash water. Analysis of the combined iron showed that a considerable amount was tied up as ferrous formate and ferrous acetate. Formic acid might well be considered the most corrosive acid of the fatty acid series. It is a more aggressive acid than acetic, with a dissociation constant of 2.14×10^{-4} versus 1.86×10^{-5} for acetic acid. The corrosion caused by both formic and acetic acids will be severe in any water washing of the gases, especially at the temperatures and pressures employed.

In view of the above it will be necessary to give the gases a pre-wash in an aqueous caustic solution before they are contacted with DEA. The caustic will of course immediately be converted to sodium hydrosulfide (NaHS) and sodium sulfide (Na_2S) by the hydrogen sulfide in the gas. The caustic present as NaHS and Na_2S will be effective in removing organic acids, since the organic acids are much stronger than hydrogen sulfide and will replace it in the salt. The sodium salt of the organic acid will be formed, and the hydrogen sulfide released. (Hydrogen sulfide has a dissociation constant of 9.1×10^{-8} for the first hydrogen and 1.2×10^{-15} for the second hydrogen vs. 2.15×10^{-4} and 1.86×10^{-5} for formic and acetic acids respectively.)

When the DEA solution is protected from organic acids by a pre-caustic wash it is felt that the Girbotol scrubbers will operate more satisfactorily both from the standpoint of hydrogen sulfide removal as well as from a great decrease in DEA consumption. It is also felt that the caustic consumption will be negligible due to the fact that spent caustic now being discarded from the gasoline treaters may be utilized in this process.

Applications of Thermodynamics to Hydrocarbon Processing

Part V

NON-HYDROCARBON FLUIDS

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IN ADDITION to hydrocarbons, petroleum refining process design calculations involve applications of thermodynamics to many non-hydrocarbon fluids, such as: air, steam, ammonia, etc. The thermodynamics required for these auxiliary fluids are simpler than that required for hydrocarbon systems, because phase and reaction equilibria are not involved for these simple gases whereas equilibrium is one of the foremost problems for hydrocarbon systems. However, the same fundamentals apply to both types of systems. This chapter is devoted to the thermodynamics of some of the auxiliary fluids encountered in petroleum refining operations, thus presenting useful thermodynamic tools for non-hydrocarbon fluids and also further illustrating the fundamentals and preparing the way for the more complicated hydrocarbon systems.

THE energy and power transformations of hydrocarbon process operations frequently employ auxiliary non-hydrocarbon fluids as heat-carrying media. This treatise of thermodynamics would not be complete without giving some attention to such fluids. The thermodynamic properties of these non-hydrocarbon fluids have been covered rather thoroughly in various books and other technical publications. Accordingly, the present chapter will be limited to the more general aspects of this subject, making references to other publications for details.

This discussion will be concerned with air, steam, water, sulfur dioxide, ammonia and carbon dioxide. Flue gas, which is a varying mixture of air, steam, carbon dioxide, etc., will be covered in a later chapter on Combustion and Flue Gases. Air, steam and water have many uses in refining units. Ammonia, sulfur dioxide, and freon, as well as some of the light hydrocarbons are used as refrigerants in hydrocarbon processing plants and sulfur dioxide is used as a solvent. Figure 10 is a thermometer chart showing the boiling points of hydrocarbons and some non-hydrocarbon refrigerants side by side. This chart is of particular interest in comparing hydrocarbons and non-hydrocarbons in the boiling range of some of the refrigerants used in industry. Space does not permit a thorough and comprehensive treatment of the thermodynamics of these non-hydrocarbons. However, a general discussion with references to the sources of more detailed information should be helpful and consistent with the objectives of this series.

Table 10 gives the constants for many non-hydrocarbon gases of interest. Boiling points, densities, critical constants and specific heats for these components vary considerably but the same thermodynamic methods are applied to all components in calculating energy changes, etc. The C_p/C_v ratios in Table 10 are of particular interest and will be discussed more in detail later.

The most useful properties that can be obtained for any fluid by means of thermodynamics are the entropy and the enthalpy, which are generally combined in the form of Mollier diagrams. In addition to entropies and enthalpies, Mollier diagrams often contain density data as well. From diagrams of this kind changes in heat and work may be readily estimated. In the previous chapter of this series a Mollier diagram was developed for the perfect gas. In subsequent chapters Mollier diagrams will be developed for hydrocarbons. The same basic principles apply to both but, of course, the details are somewhat different. Mollier diagrams are available for many non-hydrocarbon fluids; such as, steam, ammonia, sulfur dioxide, etc. References will be made to these various thermodynamic developments with some discussion of the source and the applications. Besides air and steam, particular attention will be given to carbon dioxide, ammonia, and sulfur dioxide, for which entropy and enthalpy data are available. The boiling points of these three fluids (see Figure 10), which are —112, —28, and 14 respectively, suggest the possibility of a cascade refrigeration system.

The Mollier diagram is recognized as the best thermodynamic tool to use in making energy (work and heat) change calculations for a fluid. However, Mollier diagrams are not available for all fluids, so alternate calculation methods must be used. One such alternate is to use specific heat ratios with the perfect gas compression equations to calculate temperature rise and work change on adiabatic compression. Where no other data are available, it often is possible to approximate the compression coefficient and calculate the temperature and energy changes for adiabatic and polytropic changes of a gas, particularly where the P-V-T characteristics of the gas approximate the perfect gas law. Under some conditions and with some gases this method may be used with a fair degree of accuracy for both the temperature rise and the work. For other gases and conditions, the use of the adiabatic compression or expansion coefficient (specific heat ratio) is justified in calculating the temperature change only. In these cases the temperature changes found by calculations using the specific heat ratio and by following a line of constant entropy on a Mollier diagram are in agreement but the energy changes estimated by these two methods are not in agreement. In these cases it is possible to use the coefficient method of estimating the temperature change and an enthalpy-temperature plot to estimate the heat equivalent of the work change.

Because of the prevalence and convenience of this method of making gas compression calculations, it is

worthwhile to improve the technique where possible by determining γ coefficients that will permit predicting the isentropic temperature change when used with the equation

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \qquad (134)^*$$

These γ coefficients, which may or may not be equal to the specific heat ratio, may be estimated from Mollier diagrams or by entropy calculations.

This is of sufficient interest and importance to justify space in this chapter for several non-hydrocarbon gases, determining from Mollier diagrams hypothetical γ values and comparing these with the C_p/C_v values for the corresponding perfect and actual gases. In a later chapter this will be done for hydrocarbon gases as well. Another interesting comparison, that will be made for non-hydrocarbon and later for hydrocarbon gases, is the adiabatic work of compression from the Mollier diagrams and from the perfect gas law compression horsepower equation using these hypothetical γ values.

TABLE 10

Constants for Non-Hydrocarbon Gases

Source: Worthington "Plain Talks on Air & Gas Compressors"

GAS	Formula	Mol. Weight	Specific Gravity Air=1.0	Gas Density* Lbs./ Cu. Ft.	Atmos. Boiling Point, °F.	CRITICAL		C_p/C_v*
						Temp. °F.	Pressure psia	
Air	.....	28.98	1.00	.07658	−317	−221	546	1.406
Ammonia	NH_3	17.03	0.596	.04509	− 28	270	1638	1.317
Argon	A	39.94	1.379	.10565	−302	−187	705	1.667
Carbon Dioxide	CO_2	44.00	1.529	.11637	−109	88	1072	1.30
Carbon Disulfide	CS_2	76.12	2.63	.20139	115	523	1116	1.20
Carbon Monoxide	CO	28.00	0.967	.07407	−313	−218	514	1.402
Carbon Tetrachloride	CCl_4	153.83	5.33	.4065	170	541	661	1.18
Chlorine	Cl_2	70.91	2.486	.1875	− 30	291	1118	1.33
Dichloromethane	CH_2Cl_2	84.93	3.005	.2245	105	421	1490	1.18
Ethyl Chloride	C_2H_5Cl	64.5	2.365	.1706	54	370	764	1.13
Freon (F-12)	CCl_2F_2	120.9	4.52	.3196	− 21	233	580	1.13
Helium	He	4.00	0.138	.0106	−452	−450	33	1.66
Hydrogen	H_2	2.01	0.0695	.00530	−423	−400	188	1.41
Hydrogen Chloride	HCl	36.46	1.268	.0965	−121	124	1198	1.41
Hydrogen Sulfide	H_2S	34.08	1.190	.0901	− 75	212	1306	1.30
Methyl Chloride	CH_3Cl	50.48	1.785	.1337	− 11	289	966	1.20
Neon	Ne	20.18	0.696	.0533	−410	−380	389	1.642
Nitric Oxide	NO	30.01	1.037	.0794	−240	−137	954	1.40
Nitrogen	N_2	28.02	0.967	.0743	−320	−232	492	1.41
Nitrous Oxide	N_2O	44.02	1.53	.1163	−129	98	1053	1.311
Oxygen	O_2	32.00	1.105	.0846	−297	−182	730	1.398
Sulfur Dioxide	SO_2	64.06	2.264	.1695	14	315	1141	1.26

* At atmospheric pressure and 60° F. or atmos. boiling point, whichever is highest.

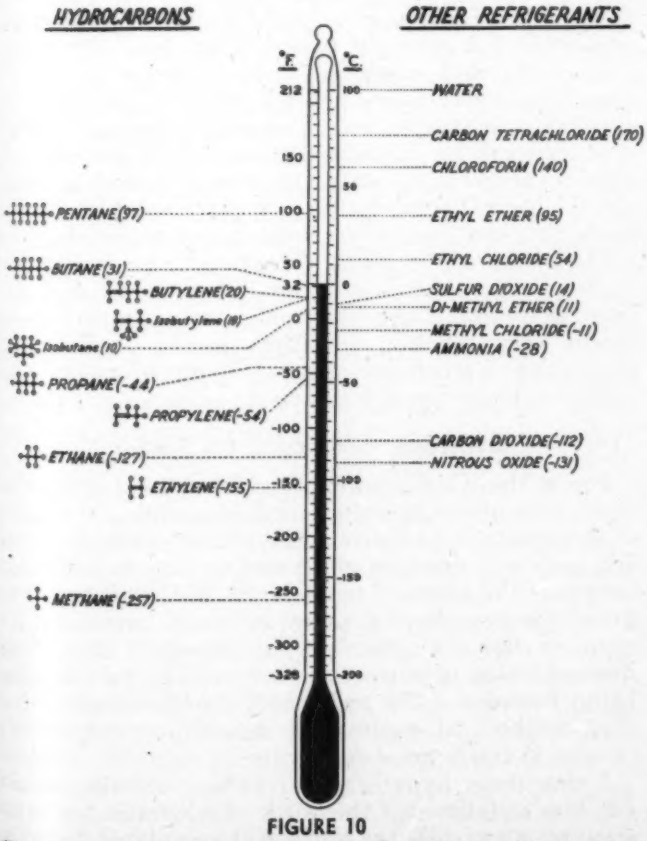


FIGURE 10

Thermometer chart giving boiling point comparisons of hydrocarbon and non-hydrocarbon fluids.
Courtesy Standard Oil Company (Indiana).

Values of C_p/C_v for Perfect Gases

By definition a perfect gas fits the P-V-T relationship of Equation 89, but it does not necessarily follow that all perfect gases have the same specific heat ratios. As a matter of fact the values of C_p/C_v for perfect gases are dependent upon the atomic structure of the gas molecule, monatomic gases having the highest value, diatomic next lower, triatomic lower than a gas having a two-atom molecule, etc. These ideal gas specific heat ratios have been worked out by spectroscopic and other methods. For a perfect gas it has been shown that $C_p - C_v = R$ (see equation 96*), from which it follows

$$\gamma = C_p/C_v = \frac{C_p}{C_p - R} \qquad (138)^*$$

The values of C_p, C_v and C_p/C_v for perfect gases of different atomic structure are as follows:

TYPE OF GAS	C_p	C_v	$\gamma = C_p/C_v$	Example
Monatomic	$\frac{5}{2}R$	$\frac{3}{2}R$	$1\frac{2}{3}$	Helium, Argon, etc.
Diatomic	$\frac{7}{2}R$	$\frac{5}{2}R$	$1\frac{2}{5}$	Hydrogen, Oxygen, Nitrogen, etc.
Polyatomic†	$\frac{8}{2}R$	$\frac{6}{2}R$	$1\frac{1}{3}$	Carbon Dioxide, Water, etc.

† Rigid molecule, neglecting vibrational energy.

These values of C_p, C_v and γ are valid only under conditions where the gas in question obeys the perfect gas laws. The above values of C_p/C_v are of particular interest because they represent upper limits approached as a gas approaches the perfect gas law

relationships. It will be noted, by reference to Table 10, that actual gas C_p/C_v values agree with these theoretical values in many cases but that in some cases the actual values are below the perfect gas values, because the gas does not behave like a perfect gas.

The magnitude of the effect of the deviations from perfect gas law on the specific heat ratios of gases will be shown later for a few gases.

All gases approach perfect gas law behavior as the pressure is lowered and the temperature increased. The temperature and pressure conditions under which a vapor follows the perfect gas law behavior closely enough to justify using the perfect gas law equations depends upon the distance from the critical point, among other things. In working with actual gases it often is necessary to use entropies rather than specific heat ratios for adiabatic compression calculations.

It will be shown later that hypothetical C_p/C_v ratios may be used for actual gases that do not follow perfect gas behavior. For simplicity, the symbol γ will be used to designate the specific heat ratio, whether real or hypothetical. The real value of C_p/C_v for an actual gas may be found experimentally by measurements of the velocity of sound through the gas. However, these C_p/C_v values may or may not be the value of γ required to predict the final temperature after adiabatic expansion or compression. Also values of C_p/C_v may be calculated for actual gases by means of thermodynamic equations, knowing the specific heat at some given conditions, for reference, and the P-V-T relations. These C_p/C_v values likewise may not give the correct final temperature after adiabatic expansion or compression.

The reason that actual, experimental or calculated, specific heat ratios often do not predict the correct final temperature for an adiabatic process is that the equations used in applying these C_p/C_v values to the problem are based on perfect gas law P-V-T behavior. One way of getting around this is to use hypothetical values of C_p/C_v or just γ, that are derived to make the temperature change calculation by the simple perfect gas law relation for an adiabatic process agree with the temperature change for a constant entropy process from a Mollier diagram.

This can only be demonstrated by using thermodynamic properties and Mollier diagrams for actual gases. Before undertaking this important calculation for several actual gases, it is necessary to have Mollier diagrams. Many such diagrams are available and can be used for this purpose. These diagrams will be discussed next, taking up steam and air first. Where tables and charts have been published, references will be made to the source. Space does not permit including these diagrams and tables in this treatise.

Steam

Steam is the most common and useful thermodynamic fluid. Steam, along with the perfect gas and air, has long been a classic *must* in the study of thermodynamics. Entering, as it does, into practically every industrial operation, its thermodynamic properties are of great importance. These properties have been the subject of systematic investigation for many years, having been started by Regnault in the middle of the 19th Century. During the past century, work on the thermodynamic properties of steam has continued in the experimental laboratories, in the computation and plotting offices, and in the standardization committees and as a result we now have accurate and consistent steam tables and Mollier diagrams for use in making steam calculations. In 1934, the Third International Conference on Steam Tables (see Mechanical Engineering, Vol. 57, 1935, page 710), established tolerances, which are followed by recently published tables and Mollier diagrams for steam. Keenan and Kaye's "Thermodynamic Properties of Steam," John Wiley and Sons (1936) was based on research work sponsored by the American Society of Mechanical Engineers and is considered more or less official with that society.

Another recent Steam Tables was published by Combustion Engineering Company in 1940. These tables and the attached Mollier diagram were derived from the equations and correlations developed by E. F. Leib and presented at the May, 1940, ASME meeting and published in the February, 1941, ASME Transactions under the title "Thermodynamic Properties of Vapors." This article was general in its scope and was not limited to steam.

Other steam tables that have been landmarks in the technical progress on steam properties are Marks and Davis (1908), Goodenough (1915) and Callendar (1924). The same general procedure was followed in developing these various steam tables. Experimental data on vapor pressures, liquid densities, vapor densities, specific heats, latent heats, and Joule-Thomson coefficients are first obtained and smoothed. From these data, equations and correlations of properties are next derived. Then the tables and charts are prepared from these derived equations and correlations.

This is the same general procedure followed in developing thermodynamic properties for hydrocarbons but there is one very interesting difference. In working with hydrocarbons, we usually have only the minimum amount of data required, or less, whereas with steam there are more data than actually required, thus making it possible to check the derived properties. For example, experimental Joule-Thomson coefficients and observed specific heats at superatmospheric pressures are not actually required in deriving thermodynamic properties because these functions can be calculated from P-V-T and atmospheric specific heat data. However, having experimental Joule-Thomson and superatmospheric specific heats provides means of checking and confirming the accuracy of the derived thermodynamic properties such as entropy and enthalpy. These additional tie-lines help make the thermodynamic properties of steam very reliable. In other words, the derived properties of steam are checked by tests furnished by available experimental evidence.

Isentropic Coefficient for Steam

From the Combustion Engineering Mollier diagram (see above reference) initial and final readings of temperature, pressure and enthalpy were made for six constant entropy processes, taken in different ranges of the superheated portion. With the data thus found the hypothetical values of γ were calculated for each of the six processes by equation 134. This derived value of γ were all very close, the variation being between 1.295 and 1.310, thus indicating that this method of estimating adiabatic temperature change is fairly good for steam.

Using these hypothetical γ values and the perfect gas law equation for the work of adiabatic compression, equation 133, the work was calculated for each of these paths and compared with the enthalpy differences. The calculated values were within —2.5 to

+6.0 percent of the Mollier diagram work quantities. Using a constant γ value of 1.30 would improve this agreement further.

This comparison for steam is of academic interest only because it is easier to use the steam tables and Mollier diagram rather than calculate in this way. It does indicate that the method is reasonably accurate, however, and might be applied where there are no other data available.

Air

Dry air is a gaseous mixture consisting of nitrogen and oxygen plus about 1 percent total of other gases, such as: carbon dioxide, hydrogen, argon, helium, etc. For most engineering purposes, these "other" gases may be neglected and dry air considered a mixture of 79 mol-percent nitrogen and 21 mol-percent oxygen. In many calculations dry air may be treated as a single gas having a molecular weight of 28.98. These "other" gases are important in the design and operation of air fractionation equipment for production of liquid oxygen.

Atmospheric air is never dry, the moisture content being known as the humidity. The amount of water vapor in the air depends upon the temperature, the pressure and the amount of water vapor available. Thus the humidity of air varies but this is the only composition variable that needs to be considered in working with air, except, of course, in air fractionation for the production of nitrogen and oxygen, which is not within the scope of this treatise. The moisture content of air is the fundamental basis for air conditioning and cooling-tower operations. These operations are at atmospheric pressure, so pressure enters into the calculations in the form of barometric and altitude corrections only.

For most practical cases, the compression of atmospheric air for the various superatmospheric air requirements, such as instrumentation, regeneration, etc., can be computed by means of perfect gas law equations, neglecting the moisture content. The low critical temperature and the validity of the perfect gas law makes air compression and expansion calculations relatively simple. Under these conditions air may be treated as a single diatomic perfect gas.

At the low temperatures and high pressures encountered in liquefaction and fractionation, air calculations become more complex. Phase conditions, composition, deviations from ideal gas laws, and effect of pressure on enthalpy and entropy are involved. Mollier diagrams for oxygen, for nitrogen and for mixtures are useful in this type of air calculations. The preparation and application of charts of this kind for oxygen, nitrogen and air involve the same procedure as for hydrocarbons. The moisture in the air and the low temperatures make drying necessary to prevent freezing. Some thermodynamic data on oxygen, nitrogen and air are available but this subject has not been as thoroughly covered as one might suppose. This is due to the limited uses for tables and charts of such data for air.

Keenan and Kaye, "Thermodynamic Properties of Air," John Wiley & Sons (1945), contains several useful tables of data for low-pressure air. These air tables are not at all analogous to the steam tables. They were developed especially for gas-turbine calculations. The principal table gives relative pressures, relative volumes, enthalpies, internal energies and entropy functions. By using relative values for pressures and volumes and also the temperature functions of entropy, the authors were able to condense a great deal of useful information into one table, which is excellent where low-pressure air calculations are being made as a routine and where high precision is required. For miscellaneous and occasional air calculations, such as encountered in hydrocarbon processing, it is usually preferable to use the basic perfect gas law equations and calculate each problem separately. For this purpose a specific heat of 0.24 may be used in calculating total heat changes for low-pressure air. This has the advantage of more clarity to the calculator. The other tables in Keenan and Kaye give values of specific heats, specific heat ratios, functions of the polytropic compression coefficient and the pressure ratio. In one of these tables the authors show the effect of temperature on the specific heat ratio, γ. Following are a few typical points to indicate the order of magnitude of this variation:

Temperature, °F. abs.	C_p/C_v for Low-Pressure Air
200	1.401
1,000	1.380
2,000	1.328
4,000	1.294
6,000	1.282

Although Keenan and Kaye do not include data in their book showing the effect of pressure on the specific heat ratio, they do include functions of variable values of the coefficient.

Data on the effect of pressure of the C_p/C_v values of air are given in Perry's "Chemical Engineer's Handbook"—McGraw-Hill, page 633. A few typical data are shown below to indicate the effect of pressure at two temperatures.

Pressure, Atmospheres	Values of C_p/C_v at	
	0° C.	—79.3° C.
1	1.405	1.405
50	1.530	1.767
100	1.646	2.200

In a later chapter, attention will be given to the effects of temperature and pressure on the specific heat ratios of hydrocarbons.

Isentropic Coefficient for Air

The thermodynamic properties of dry air at low temperatures have been compiled by V. C. Williams and published in Trans. Am. Inst. of Chem. Eng. Vol. 39, page 93 (1943). This article not only presents tables and diagrams of thermodynamic properties but also gives a very clear description of the development of these items from the experimental data and the basic equations. Reference may be made to this publication for more details and for the charts and tables.

Using the Williams Mollier diagram for air, hypothetical values of γ were derived for several isentropic paths, taken in such a way as to cover the superheated region from the saturated vapor line to the upper range of the chart. This was done by reading initial and final temperatures and pressures for each path, substituting in Equation 134 and solving for γ. For 15 paths, covering temperatures from —288° F. to 40° F. and pressures from 1 to 145 atmospheres, for which values of γ were computed, the results were between 1.465 and 1.530 and averaged 1.504. Some of this variation is probably due to the inaccuracy of reading the small-scale charts and some probably due to irregularities and inconsistencies in the charts. It is believed that better agreement would have been obtained by using the tabulated data. From the results obtained it appears that the temperature and pressure do not cause variations in hypothetical γ for air. It might be concluded that γ for air is independent

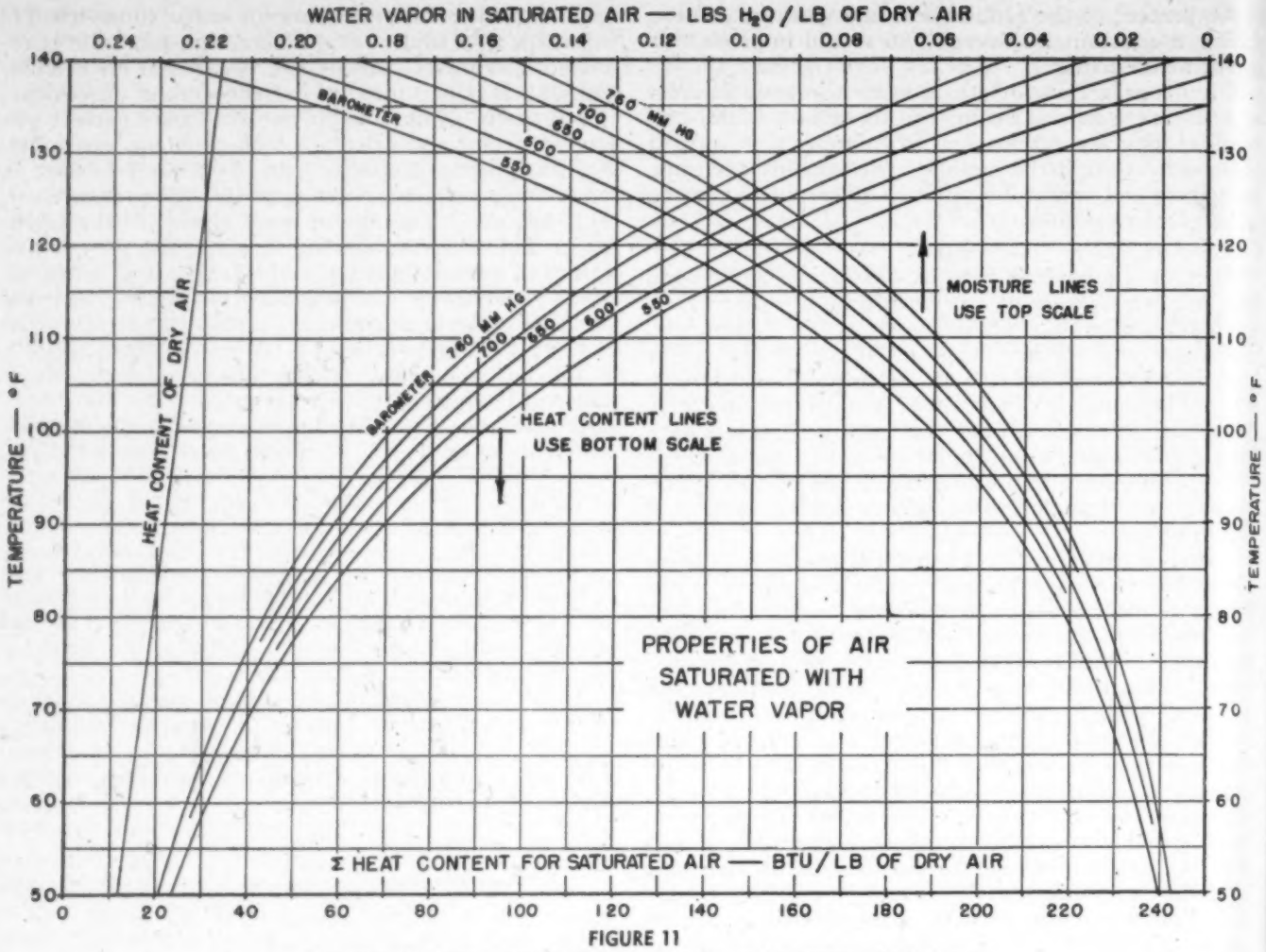


FIGURE 11

Properties of air saturated with water vapor for cooling-tower calculations.

of temperature and pressure and that a value of 1.504 should be used.

It is interesting to note that this hypothetical value of γ is higher than the value of C_p/C_v for diatomic gases and also higher than the C_p/C_v for atmospheric air. This is due to the thermodynamic behavior of air as reflected in the entropy and enthalpy relations.

The adiabatic work values for each of these isentropic paths were also found from the Mollier diagram and calculated by the perfect gas law equation using the hypothetical γ values. The perfect gas law work quantities were from 10 to 50 percent higher than the values found from the Mollier charts. These deviations were of greater magnitude at the higher pressures. It may be concluded that the hypothetical value of γ may be used to estimate temperature changes for isentropic compression, however.

Humid Air

Air is used to cool water in natural, forced and induced-draft cooling towers and spray ponds. This transfer of heat is effected by bringing the air and water into direct contact where heat is transferred from the water to the air as the temperature and the moisture content of the air increase accordingly to maintain constant total heat content. This process is one example of humidification, which, along with dehumidification, form the basis for air-conditioning. The Psychrometric Chart, which was developed in 1909 by Grosvenor and which has been improved by many since then, is a very useful thermodynamic tool for humidification and dehumidification calculations.

This discussion of humid air will be concerned with cooling-water calculations only, which do not require the Psychrometric Chart, although parts of it are applicable. In order to simplify the problem, a chart has been prepared for cooling-tower calculations and will be presented in this discussion. In order that this chart be as clear as possible and its relationship to the Psychrometric Chart and the steam tables be thoroughly understood, sample calculations are included to show the development of both this chart and the Psychrometric Chart.

A Psychrometric Chart covers the complete range of moisture content of air; namely, from dry air to saturated air (0 to 100 percent relative humidity), wet- and dry-bulb temperatures being used as the index of saturation. In cooling-tower calculations, only the wet-bulb temperature and the saturated (100 percent relative humidity) air portions of the Psychrometric Chart are of interest because the air is saturated in the presence of water in a cooling tower.

Cooling-tower calculations involve: (1) balance of heat between water being cooled and saturated air doing the cooling, and (2) rate of heat transfer from water to air by convection and diffusion and contact surface required. Cooling-tower heat balances are of interest from a thermodynamic point of view. The heat removal from the water in cooling it is accomplished by vaporizing a small portion of the water. Regardless of the dry-bulb temperature of the entering air, the cooling capacity of air is determined by its wet-bulb temperature.

If the dry-bulb temperature is higher than the wet-

bulb temperature, which means that the air is partially saturated with water vapor and the relative humidity is between 0 and 100 percent, the atmospheric air will rapidly pick up moisture as soon as it enters the cooling tower, becoming saturated and cooling down to the wet-bulb temperature before the transfer of heat from the main body of water to the air begins. Thus wet-bulb or dew-point temperatures of the air are involved in cooling-tower calculations. The temperature of the cooled (or cold) water will always be higher than the wet bulb of the inlet air, the approach depending upon the relative quantities of air and water and the contacting area.

Although the Psychrometric Chart gives the necessary enthalpy vs. temperature data required for saturated air in making water-cooling calculations at sea-level conditions, a more convenient chart for this purpose has been prepared from fundamental data and is presented here as Figure 11. This chart was prepared in the following manner, using data from steam tables:

The amount of water vapor in saturated air is calculated from the vapor pressure of water at the temperature in question, the atmospheric barometer, and the molecular weights of the air and water.

$$\text{Water Vapor in Sat. Air} = \left(\frac{p}{P-p}\right)\left(\frac{18.02}{28.97}\right) \text{ lbs. } H_2O/\text{lb. Dry Air}$$

where: p = vapor pressure of water
P = atmospheric barometer
Vapor pressure and barometer values must be in consistent units.

Using this equation, the water vapor figures were computed for five different barometer readings (from 760 to 550 mm. Hg.), and temperatures from 50° to 140° F. These results are plotted as one parameter of Figure 11.

The vapor pressures for this calculation were obtained from the Steam Tables. The heat content lines were calculated from these moisture values, saturated steam enthalpies from the steam tables and a specific heat of 0.24 Btu/lb.-°F. for air. The datum point for the heat contents is 0° F. for dry air and liquid at 32° F. for the water vapor. Total heat content of dry air is represented by one curve on Figure 11. To these heats are added the enthalpies of the water vapor to get Heat Content for the saturated air. These calculations were made for the same five (760 to 550 mm. Hg) barometer readings and the results plotted on Figure 11.

Following are sample calculations for the preparation of Figure 11:

Temp. °F.	Vapor Press. Inches-Hg	Total Btu/Lb. Dry Air Above 0° F.	Total Btu/Lb. Water Above 32° F. Liquid	760 mm. Hg (29.92 in Hg) P_{-p}	W	h_w	Σ	600 mm. Hg (23.6 in Hg) P_{-p}	W	h_w	Σ
50	0.3624	12.07	1082.9	29.56	0.0076	8.26	20.33	23.26	0.0097	10.50	22.57
100	1.931	24.16	1104.4	27.99	0.0431	47.56	71.72	21.69	0.0555	61.25	85.41
140	5.878	33.85	1121.6	24.04	0.1532	171.9	205.75	17.78	0.2073	232.3	266.15

Figure 11 gives the moisture contents and total heats for saturated air only and in this respect is more limited than the Psychrometric Chart. However, Figure 11 covers a wide range of atmospheric barometer reading, whereas the Psychrometric Chart is for sea level with tabular corrections for altitude.

The Σ Heat Content of air and water vapor is sometimes expressed as Humid Heat in Btu/°F.-lb. dry air. Since the specific heats of dry air and water vapor are substantially constant at 0.24 for air and 0.43 for steam, the equation for the humid heat is

$$h = 0.24 + 0.43\,w \qquad (139)$$

Humid heat is a function of the humidity expressed as lbs. H_2O/lb. of dry air and independent of temperature. For saturated air the total heat content can be plotted against temperature as shown in Figure 11.

This logically brings the discussion to partially saturated air. If air at any temperature and moisture content is raised or lowered in temperature by varying the moisture content but with the heat content constant, an adiabatic humidification curve results. One end of this curve is the saturation or wet-bulb temperature and the other end is the dry-bulb temperature, where the air contains no moisture. This adiabatic change in moisture content is the process air goes through in all cases where no heat is added or removed from the system. The heat content is a function of wet-bulb temperature and not the dry-bulb temperature. The dry-bulb temperature only indicates the degree of moisture saturation of the air, the greater the difference (dry-bulb temperature is always greater than the wet-bulb temperature for partially saturated air), the dryer the air.

The moisture content for any air conditions, as defined by the wet- and dry-bulb temperatures, can be found by means of a simple heat balance from data given on Figure 11 and in the steam tables. For example, calculate the absolute humidity of air having an 80° F., wet-bulb temperature and a 110° F. dry-bulb temperature. Figure 11 and the steam tables will be used in making this calculation and the results checked on a Psychrometric Chart.

From Figure 11 the following readings are made for saturated air at 80° F.: water vapor content = 0.0225 lbs./lb. dry air, and Σ heat content = 43.5 Btu/lb. dry air. From Figure 11 the heat content of dry 110° F. air is found to be 26.5 Btu/lb. From the steam tables, the heat content of saturated water vapor at 110° F. is found to be 1108.8 Btu/lb. The heat content of the air in question is the same as the saturated air, which is 43.5 Btu/lb. dry air.

$$\text{Moisture in 110° F. air} = \frac{43.5-26.5}{1108.8} = 0.0153 \text{ lbs. } H_2O/\text{lb. dry air.}$$

From Psychrometric Chart, the moisture content of 110° F. dry-bulb and 80° F. wet-bulb air is given as 106.5 grains/lb. dry air, which is equivalent to $\frac{106.5}{7000}$ = 0.0152 lbs. H_2O/lb. dry air.

Although Figure 11 can be used in humidification and dehumidification calculations, it is primarily intended for cooling-tower calculations, where only saturated air is involved. As an example, Figure 11 will be applied to the following problem:

Heat to be dissipated by the cooling tower	= 100,000,000 Btu/hr.
Hot water to tower	= 120° F.
Cold water from tower	= 90° F.
Wet bulb temperature	= 75° F.
Barometer	= 700 mm. Hg (27.6 inches Hg)

Assume that the tower is of such a size and design that a uniform 15° F. approach temperature can be maintained by blowing sufficient air through the tower. Thus saturated air at 75° F. inlet and at 105° F. outlet are the conditions used in the calculation. From Figure 11, the following data are obtained for saturated air at 700 mm. Hg.

Temperature, °F. Saturated Air	Σ Heat Content Btu/lb. dry air	Moisture Lbs. H_2O/lb. dry air
105	86	0.0555
75	40	0.0210
Difference	46	0.0345

The solution follows:

$$\text{Water Circulation} = \frac{100{,}000{,}000}{(120-90)} = 3{,}330{,}000 \text{ lbs./hr.}$$

$$= \frac{3{,}330{,}000}{8.33 \times 60} = 6{,}775 \text{ GPM}$$

$$\text{Air Throughput} = \frac{100{,}000{,}000}{46} = 2{,}175{,}000 \text{ lbs./hr.}$$

$$\text{Ratio: } \frac{\text{Water}}{\text{Air}} = \frac{3{,}330{,}000}{2{,}175{,}000} = 1.53$$

$$\text{Evaporation} = 2{,}175{,}000 \times 0.0345 = 75{,}000 \text{ lbs./hr.}$$

$$= \frac{75{,}000}{3{,}330{,}000}\ 100 = 2.25\%$$

This amount of evaporation is based on the assumption that the inlet air was saturated. If the inlet air is dry, the evaporation loss would be 3.62 percent of the circulation instead of 2.25 percent. In most cases the inlet air is partly saturated so the evaporation loss is between these extremes or about 3 percent, which is 1 percent for each 10 percent of cooling. This loss does not include drift or windage losses, which are dependent upon the tower design.

The design of the cooling tower must take into consideration the approach, range, wet bulb, quantities of air and water, and the altitude or barometer. Cooling-tower design is outside the scope of this article.

Ammonia

Because of its very suitable thermodynamic properties, ammonia is one of the most widely used refrigerants. By reference to Figure 10 it can be seen that ammonia boils slightly higher than propane and lower than isobutane. Tables of properties and a Mollier diagram have been avilable many years for ammonia. Circular No. 142 of the Bureau of Standards, first issued April 16, 1923, contains tables of thermodynamic properties of saturated and superheated ammonia and also a pressure-enthalpy type Mollier diagram. Goodenough's "Properties of Steam and Ammonia," John Wiley and Sons, New York; 1915, made thermodynamic properties of ammonia available before then.

The properties of ammonia were prepared in the same manner used for steam. The Bureau of Standards compilation of ammonia properties were based on the following measurements: vapor pressures, densities of saturated liquid and vapor and superheated vapor, latent heat of vaporization, specific heat of liquid and vapor, and Joule-Thomson coefficients. Reference is made to the Bureau of Standards Circular (No. 142) for a description of this work.

Isentropic Coefficient for Ammonia

From the Mollier diagram given in this bulletin, final temperatures for several adiabatic (isentropic) changes were found. From these initial and final conditions the values of γ, the hypothetical specific heat ratio, or the isentropic compression coefficient, were estimated for each of five constant entropy processes with varying initial and final conditions so as to cover most of the superheated vapor region. Equation 134 was used in making these calculations. All five of these estimated γ values were in the range 1.29 to 1.30, as compared with a value of C_p/C_v of 1.317 in Table 10. The fact that all five of these γ values were so close together indicates that this method may be used in estimating temperature changes in adiabatic compression and expansion. The difference between these γ values of 1.295 (average) and the C_p/C_v value of 1.317 from Table 10 does not necessarily represent deviation from perfect gas behavior, although it could.

Ammonia is a polyatomic gas and if a perfect gas would have a C_p/C_v value of 1.333 as compared with the 1.317 and 1.295 values discussed above.

Using these hypothetical values of γ the work of adiabatic compression was calculated by using equation 133. These work figures were compared with the isentropic differences in enthalpy for the same conditions. The calculated work values were greater than the Mollier diagram work values by from 4 to 9 percent. The lack of agreement indicated that the adiabatic compression work for ammonia can not be estimated by the perfect gas law equations, even when using the hypothetical γ, although the temperature change can be estimated in this way.

Sulfur Dioxide

Sulfur dioxide is widely used in the petroleum industry as a solvent and a refrigerant. SO_2 boils at a temperature near the butanes as can be readily seen by reference to Figure 10. As non-hydrocarbon refrigerants, ammonia and sulfur dioxide may be used in different but overlapping ranges. A brief review of SO_2 thermodynamics will show the way to more specific studies and also help develop short-cut tools for hydrocarbons.

The thermodynamic properties of sulfur dioxide were developed recently by D. F. Rynning and C. O. Hurd of Shell Development Company (Trans. Am. Inst. of Chem. Eng. 41, 265 [1945]). These properties were derived from very few experimental data by the application of generalized methods and correlations, some of which were based on hydrocarbons. In spite of the lack of observed data for cross checking, these thermodynamic properties of SO_2 should be reliable for hydrocarbon processing calculations because properties are consistent due to methods of preparation.

Isentropic Coefficient for SO_2

Using the SO_2 Mollier diagram contained in this article, hypothetical values of γ were found for nine isentropic paths. This was done by finding initial and final temperatures and pressures from the isentropic paths and then computing γ from Equation 134. These nine values of the hypothetical γ for SO_2 were all between 1.240 and 1.288 as compared with $C_p/C_v = 1.333$ for a perfect polyatomic gas, and $C_p/C_v = 1.256$ given in Table 10 for SO_2.

The adiabatic work of compression was found for each of these paths by two methods: (1) difference in enthalpies between initial and final conditions on the constant entropy paths; and (2) perfect gas law work of adiabatic compression equation, using hypothetical values of γ. The calculated work values were from 0 to 17 percent higher than the Mollier diagram work values.

This lack of agreement on work and the agreement on hypothetical γ values indicate that temperature changes for adiabatic compression may be calculated by perfect gas law equation but that the work of adiabatic compression cannot be calculated in this way.

Carbon Dioxide

Carbon dioxide boils almost as low as ethane and would be a suitable refrigerant for lower temperature than could be reached with ammonia. From a thermodynamic point of view, the manufacture of solid carbon dioxide or dry ice is of interest. The CO_2 in flue gas usually does not require very much thermodynamics, with the possible exception of flue-gas blowers. Here, as in other cases, the thermodynamic tools are developed to suit problems requiring them.

On page 545 of Perry's "Chemical Engineer's

Handbook" the following C_p/C_v values are given for carbon dioxide.

°C	C_p/C_v
−75	1.37
+15	1.304

The value of C_p/C_v for +15° C. is close to the hypothetical values of γ found from the T-S diagram (see below). However, the value of C_p/C_v for −75° C. is appreciably higher than the derived γ's discussed above. This low temperature range was covered in this hypothetical derivation so we can conclude that the value of 1.37 is too high for use in calculating the work and temperature rise for adiabatic compression, although 1.37 may be the correct value of C_p/C_v at this condition.

A temperature-entropy diagram for CO_2 may be found (facing page 662) in "Chemical Engineering Thermodynamics" by B. F. Dodge, McGraw-Hill, New York (1944). This chart, which is dated January 8, 1930, was transposed from the German data of Plank and Kuprianoff (Z. ges. Kalte. Ind. Beihefte 1, 10-65 [1939]) and constructed by F. H. Hunt of Liquid Carbonic Corporation. Being on temperature-entropy scales the chart is constructed with lines of constant enthalpy.

Isentropic Coefficient for CO_2

From this T-S diagram, hypothetical values of γ were computed for seven constant entropy paths in different regions of the chart. These values of the hypothetical γ were computed in the same way described above for steam, ammonia, and sulfur dioxide. Initial and final temperatures and pressures were read from the chart and γ calculated from equation 134. The resulting γ's varied from 1.285 to 1.325 and averaged 1.30, which average figure agrees with the figure for C_p/C_v given in Table 10.

For these same isentropic paths, initial and final enthalpies were read from the T-S diagram and the work of compression calculated as the difference. The works for adiabatic compression were also calculated by equation 133 using the derived γ values. These calculated results were consistently higher (0 to 7.3 percent) than the enthalpy results.

The variation of real C_p/C_v with temperature for hydrogen is shown by the data given on page 545 of Perry's "Chemical Engineer's Handbook," which data follow:

°C	C_p/C_v
−181	1.597
− 76	1.453
+ 15	1.410

The value for +15° C. agrees with the figure given in Table 10 for hydrogen. From the above findings on carbon dioxide we might conclude that higher values than 1.41 should not be used for hydrogen in lower temperature ranges.

Values of C_p/C_v and γ for Isentropic Changes

In this chapter three types of adiabatic isentropic compression coefficients are discussed; namely, (1) the perfect gas C_p/C_v values, (2) the real C_p/C_v values for actual gases, and (3) hypothetical γ values. The perfect gas C_p/C_v values are based on theoretical considerations and depend on the molecular structure of the gas. For any one gas the perfect gas C_p/C_v are constant and independent of temperature and pressure. The real C_p/C_v values for actual gases are found by velocity of sound measurements or by thermodynamic measurements and calorimetric data. Real C_p/C_v for actual gases vary with temperature and pressure as shown by the data presented for air and other gases.

The hypothetical values of $\gamma \neq C_p/C_v$ (the $\neq$ symbol is used to indicate that γ is analogous to but not equal to the C_p/C_v ratio), obtained from Mollier diagrams for actual gases, required to predict the temperature change on isentropic compression or expansion, differ somewhat from the corresponding perfect gas C_p/C_v and the actual C_p/C_v, the magnitude of the difference depending upon the gas in question and the conditions. Also, and very important, the hypothetical values of γ do not appear to vary with temperature or pressure. This last fact, if confirmed by a more detailed investigation, simplifies calculations greatly, particularly for hydrocarbon mixtures. In a later chapter, similar hypothetical values for γ will be found for the hydrocarbons.

In discussing the derivation of the hypothetical values of γ for various gases, the low, high and average values of γ were given. A review of the conditions and calculations reveals no trends that would indicate a variation of γ with temperature or pressure. Neither did compression ratio affect the derived γ values. It must be concluded, at least temporarily, that the variation in these results reflect inconsistencies and/or errors in the entropy-enthalpy data used and also human errors in reading the charts and making the calculations. A 10-inch log-log slide rule was used. Accordingly, it is recommended that average γ values be used. Table 11 is a summary tabulation comparing the three γ values.

TABLE 11
Comparison of γ Values for a Few Gases.

	Perfect Gas C_p/C_v	Actual C_p/C_v‡	Derived Hypothetical Average γ‡ Values
Air	1.400	1.405	1.504
Hydrogen	1.400	1.410	....
Steam	1.333	.....	1.300
Ammonia	1.333	1.317	1.295
Sulfur Dioxide	1.333	1.256	1.258
Carbon Dioxide	1.333	1.304	1.300

‡ All at approximately standard conditions. The effects of temperature and pressure are not included in these data. Actual C_p/C_v ratios are effected but hypothetical values of γ do not appear to be.

From equation 134, it is easy to find the effect of errors in γ on the final temperature. This effect varies with compression ratio and on the initial temperature. It will also depend upon the γ value. For a γ of 1.30 to 1.35 a difference of 0.01 in the γ value (e.g., 1.31 to 1.32) will cause a 1 percent error in final absolute temperature at a compression ratio of 5 and a 1.7 percent error at a compression ratio of 20. If the initial temperature of the gas is 80° F. these errors represent 5° F. and 9° F., respectively, differences in the final temperatures. A compression ratio of 5:1 is near the upper range of most industrial practice. From this it can be seen that the probable error in final temperature makes it desirable to have as reliable values of γ as possible.

It is not recommended that the hypothetical γ values be used in the perfect gas adiabatic compression work equation for the computation of the work of compression for actual gases. The results of this study indicate that this might lead to appreciable errors in some cases. However, in some cases this would be better than using actual C_p/C_v values in this way. A more accurate procedure would be to use a temperature enthalpy chart and find the work as the difference in enthalpies at the initial and final conditions. Charts of this type could be constructed more easily than entropy-enthalpy charts. The advantages of this technique will become apparent in a later chapter when working with hydrocarbon mixtures.

[End of Part V; Part VI will appear in the next issue.]

Study of Refinery Maintenance Results in Handy Portable Tools

IN THE Houston refinery of the Shell Oil Company portable tools and special equipment are employed to speed maintenance operations and shorten down-time on process units. Where practical, manufactured equipment commercially available has been utilized, but in many cases special devices have been devised to accomplish some specific task. Plant engineers have studied routine maintenance operations for which they are responsible, and have over a period of time been able to make many improvements. It is believed that several of the ideas utilized will be of interest to refinery men generally, and for this reason brief descriptions and photographs are presented.

The portable pipefitters vise (Figure 1) and cabinet for pipefitting tools (Figure 2) is easily moved at any job site and is sturdy enough so that threads can be cut and pipe fittings made up in the pipe vise. Enough space is available for the storage of tools so that the pipe fitter can avoid extra trips to the toolroom.

Pipe bending at the job site is accomplished with the portable hydraulic pipe-bending machine which can handle sizes through 4 inches. (See Figure 3.)

Connections to pipe lines under operating pressure are readily performed by use of special pipe-drilling machines (Figure 4). Holes from 3 to 12 inches can be drilled and the machine is applicable to all line sizes above 4 inches. To make a tie-in to a line under pressure, a stub and a flange is first welded to the operating line, a gate valve is bolted to the flanged connection, the drilling machine is attached to the flange of gate valve, which is opened, and the required hole is cut into the operating line. An air motor supplies driving power for the machine. The gate valve is closed after the drilling operation is completed to allow removal of the drilling tool.

Air-Operated Hoist

The air-operated hoist mounted on a portable hand truck (Figure 5) is typical of a number of such tools which are used to expedite handling of materials in process units during shutdowns. They are termed "tugger hoists."

A portable boring machine (Figure 6) has been designed and built in the plant machine shop for

FIGURE 1
Portable Pipefitter's Vise

FIGURE 2
Portable Cabinet for Pipefitting Tools

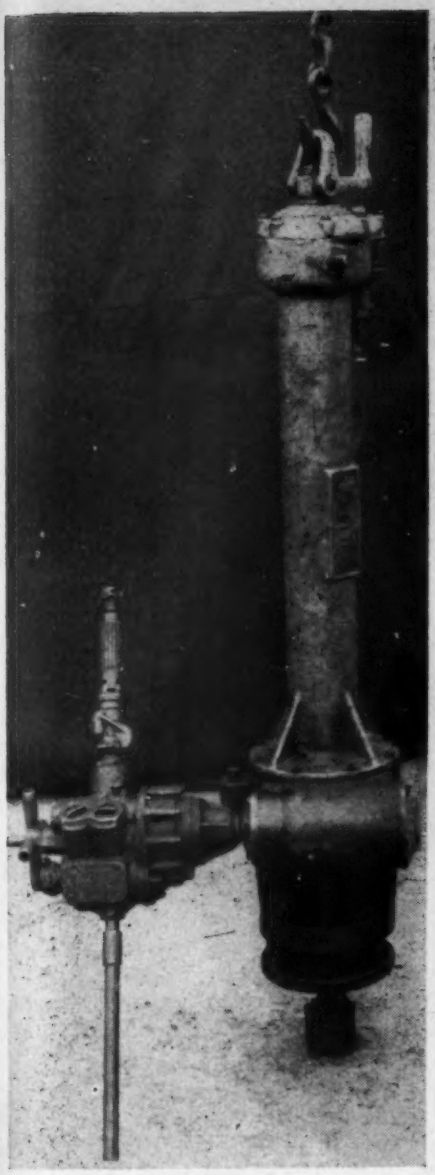


FIGURE 4
Pipe-Drilling Machine

FIGURE 3
Portable Hydraulic Pipe-Bending Machine

FIGURE 5
Easily Portable Air-Operated or "Tugger" Hoist

use in regrinding valve seats of gas compressors. The machine is shown in use, bolted to the cylinder of a compressor. A spindle is provided for driving the machine with a portable air motor through a reducing gear.

Changes of oil in gas compressor crankcases are expedited with a small motor-driven movable pump, which serves to withdraw spent oil and refill with fresh lubricant as occasion demands. (See Figure 7.)

In the pipe shop a machine (Figure 8) has been devised for the cutting of gaskets, thereby effecting a considerable saving in gasket cost, as well as reducing the stock of ready-cut gaskets which must be maintained.

Metal reinforced gannister is used for lining towers and tanks. A special tool, as shown in Figure 9, has been devised to form the metal dowels required for these linings. Dies, which fit a standard punch press, require only that an operator feed the proper size wire, which is automatically formed to the correct shape, cut off, and ejected.

An important feature of the maintenance program is a fast tool delivery system which uses a full-time truck and driver to reduce time losses of craftsmen and their helpers in making trips to the plant tool room. It was estimated that the peak tool room load occurred in mid-morning when craftsmen had surveyed their jobs after which they usually would be forced to make a second trip to the tool room for additional equipment. It is this second trip which has been eliminated with worthwhile savings. Figure 10 shows the type of portable tool stores in use on maintenance shut-down jobs at Shell's Wood River, Ill., plant.

Valuable time saver in major equipment repair and replacement is a "self loading" trailer which can be quickly released from its winch truck pull-

FIGURE 6
Portable Boring Machine which is used for regrinding valve seats of gas compressors

ing unit and lowered to form an inclined runway on to which such equipment items as heat exchanger bundles, pumps, and compressors can be readily pulled by the disengaged winch truck (Figures 11 and 12). When the equipment to be transported is in place the forward end of the trailer can quickly be raised and locked to the tractor unit by use of hoisting equipment on the winch truck. When the trailer is to be unloaded the operation is reversed.

"Load lugger" trucks form the basis of a system of scrap material disposal which is most effective. Metal "buckets" are spotted throughout the plant at strategic locations for the disposal of scrap materials from maintenance operations, trash, and even garbage from the company cafeteria. A regular collection schedule by the load lugger trucks is followed, each bucket being transported to the appropriate disposal point.

A number of devices and standard procedures not covered here are utilized by the plant maintenance staff. Many of these are in general use in other refineries; in any case the important feature of the "efficiency program" at Shell's Houston plant is not primarily the development of individual labor saving devices, but rather an overall planning which investigates routine maintenance operations thoroughly, and then attempts the economic solution of specific problems by whatever means are available.

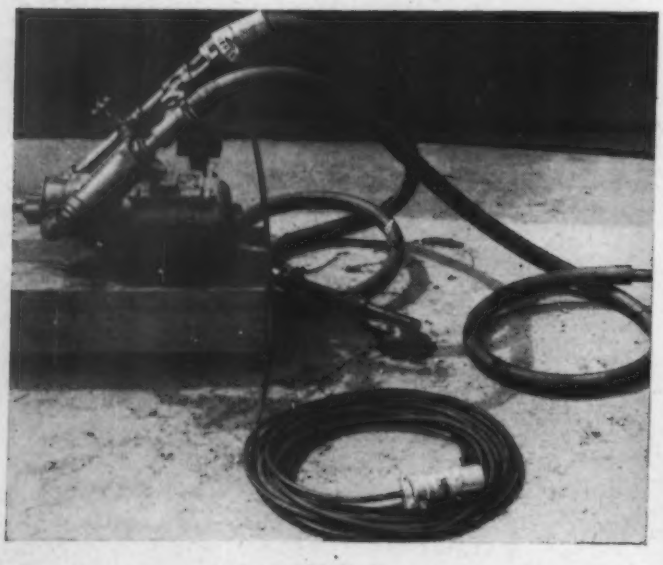


FIGURE 7
Pump for Crankcase Oil Changes

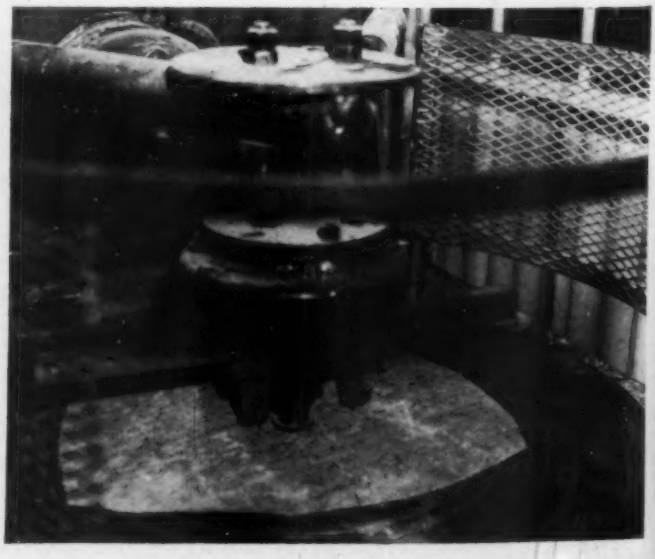


FIGURE 8
Machine Designed for Cutting Gaskets

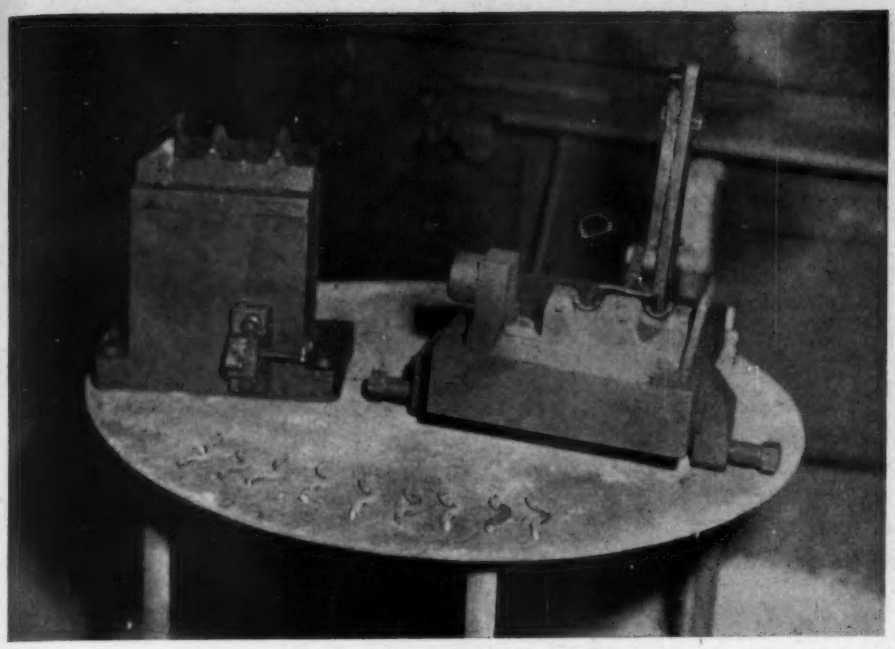
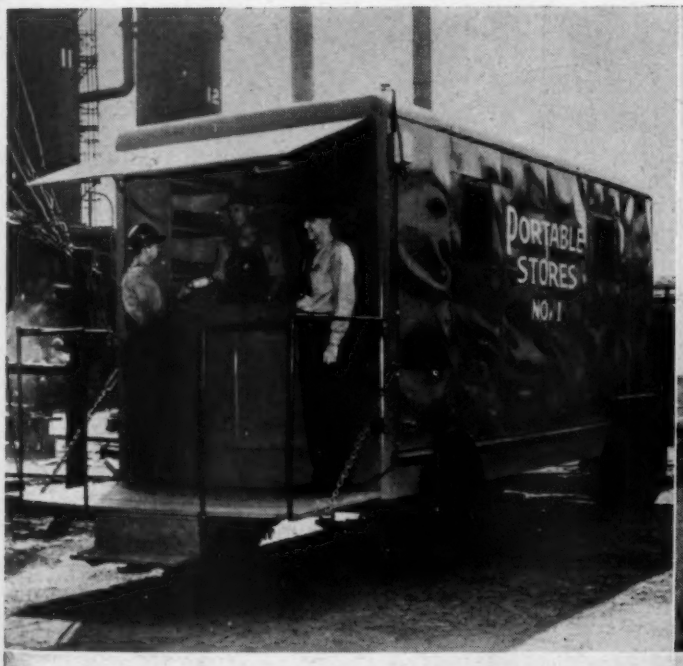


Figure 9 (top left) is a Shell-developed machine which forms metal dowels used in tank and tower lining work this as described in article which is concluded on the preceding page.

Figure 10 (left center)—Portable tool stores trailer, developed at Shell's Wood River, Ill., plant, bring to the job area large quantities of material and thus facilitates supplying the big crew of men. In one period of six weeks, the trailer served four shutdowns (20 working days) and filled 1100 orders that accounted for 92 percent of everything needed. Used only on major jobs, the well-designed storeroom draws material from central stores on general plant account and issues it to workmen on the job without order forms. Shell figures a portable store pays for itself in three months and it plans to build them for other refineries.

Figures 11 and 12 (upper right and lower left)—"Self-loading" trailer which forms inclined runway for easy loading when disengaged from its winch truck.

Figure 13 (lower right)—"Load lugger" truck used in scrap material disposal system.



Control Equipment for Hazardous Locations

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IN THIS article the author briefly reviews the types of electric power circuit control equipment available for installation in hazardous locations and outlines most suitable applications. He discusses control equipment size ranges that above a certain practical and economic limit for explosion proof equipment other means of protection are more suitable.

IN THE past two decades, the requirements for special equipment for installation in so-called hazardous locations have multiplied rapidly. There are two general types of hazards involved, each presenting its own peculiar problems.

The first of these, hazardous gases, is found in a variety of places. Refineries of today require installation of control equipment in many locations where explosive mixtures of air and gasoline, or other volatile petroleum products, are present. Distribution points where petroleum derivatives must be handled also require, in some degree, explosion-proof equipment.

Industrially, there are many areas where the use of the same type of equipment is required, or advisable. Certain chemical processes present a potential hazard where arcing electrical controls may ignite air-gas mixtures, which are likely to be present despite modern ventilating equipment. Painting areas, and storage places for solvents and inflammable liquids are other typical applications. Certain areas in hospitals where ether is stored or used must be protected against explosions caused by arcing electrical apparatus.

Dust Explosion Problem

Dust is the other type of potential hazard. The most common example of this category is the grain elevator, or in processing areas in granaries where the grain dust can become suspended in the air in lethal proportions should an open flame or spark be present. Gunpowder plants obviously require protection against the presence of sparks in proximity to the materials or the finished product. Metal chips and dust (such as magnesium) present a problem under specific conditions, as do many chemicals in powder or granulated form. Other typical areas requiring special attention are grain processing plants, starch plants, sugar purifying plants, milling plants, hay grinding plants, and coal purifying machinery.

The Underwriters' Laboratories, Inc., has recognized the need for standards for equipment destined to be installed in hazardous locations and has published such standards for most types of hazard

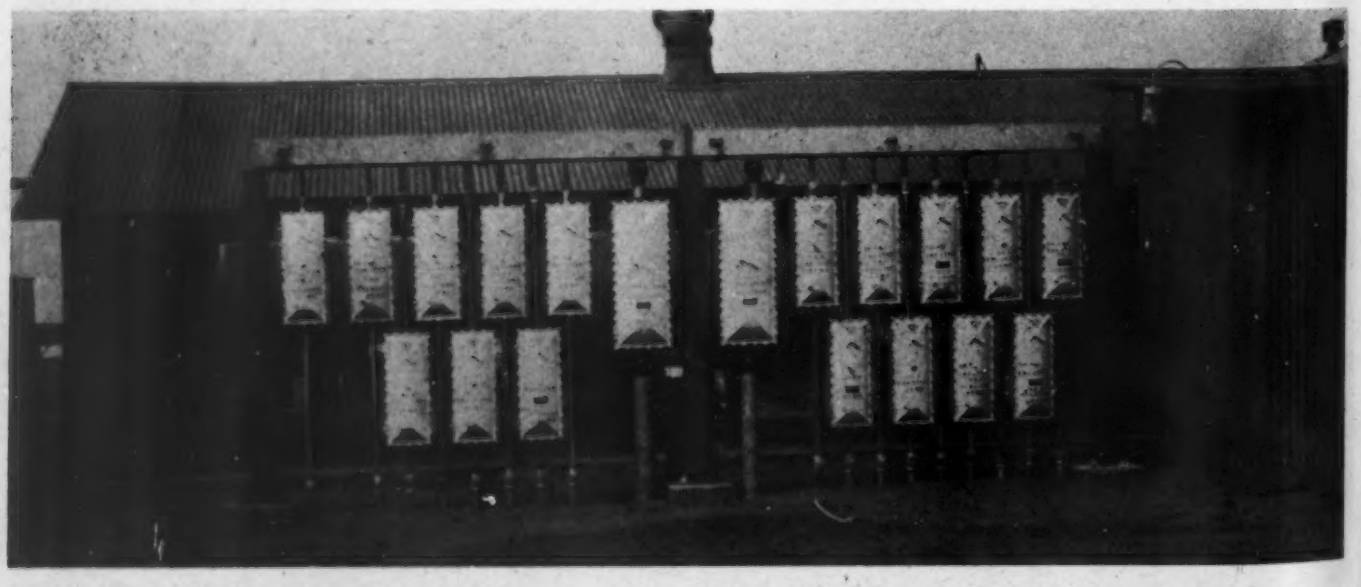


Figure 1—Typical concentration of air-break explosion-proof starters installed in a non-corrosive but highly hazardous refinery area.

for the guidance of manufacturers of electrical equipment. Most control manufacturers have either submitted their designs for approval by the Underwriters' Laboratories, Inc., or have familiarized themselves with the requirements so that they can build equipment in accordance with their interpretation of the standards.

Without going into detailed description of the equipments, it can be said that, in general, air-break control for Underwriters' Class I (hazardous gases) (Figure 1) is built to withstand an explosion in the enclosure and to prevent its spreading to the surrounding atmosphere. Oil-immersed equipment, which will be discussed more in detail later in this article, is so constructed that all arcing parts, joints, terminals, and electrical connections are below the oil level and is designed to prevent any possibility of sparks above the oil level.

Equipment for Underwriters' Class II (hazardous dust) locations is built to prevent dust from entering the enclosure. This, of course, makes for a considerably lighter construction than the Class I designs, because the enclosure cannot be subjected to internal explosion. Oil-immersed equipment is not used for this class of hazard because corrosion problems are not usually encountered in such areas. Furthermore, there are no existing standards covering the use of oil-immersed apparatus in hazardous dust locations.

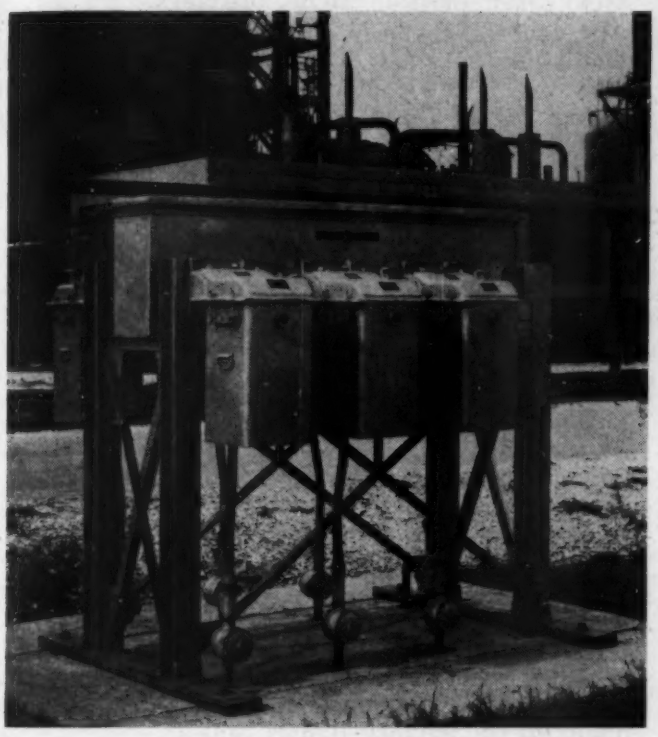


Figure 2—Typical modern "racked-up" control center assembly of oil-immersed starters installed in a hazardous refinery location.

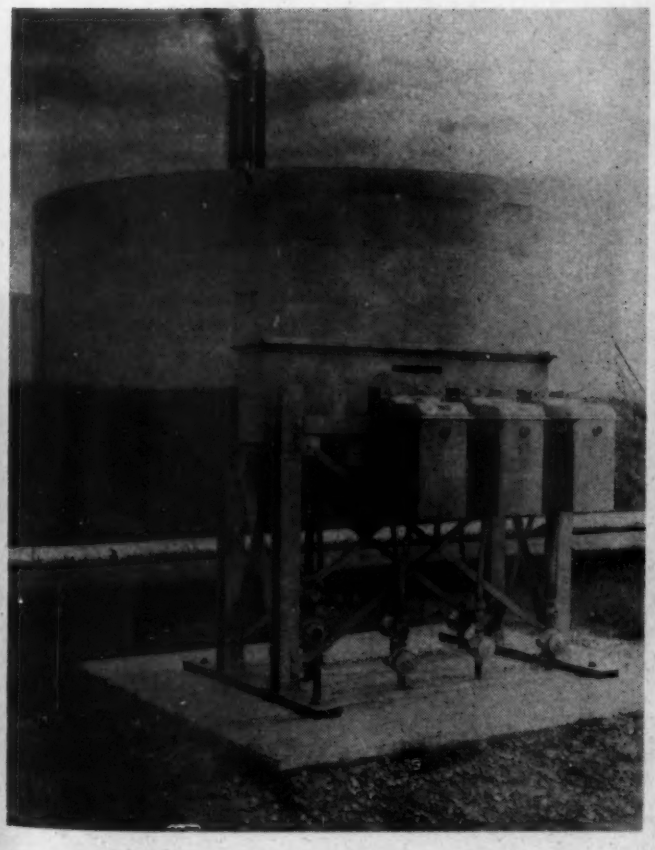


Figure 3—Another typical modern "racked-up" control center assembly of oil-immersed starters installed in a hazardous refinery location.

Economical Size Limit

The increased demand for explosion-proof apparatus has resulted in a gradual building up of the lines of control equipment offered by the various manufacturers. The Underwriters' Laboratories, Inc., approves and tests apparatus up to 30 hp only. This seems to cover almost all the requirements for equipment which must be mounted

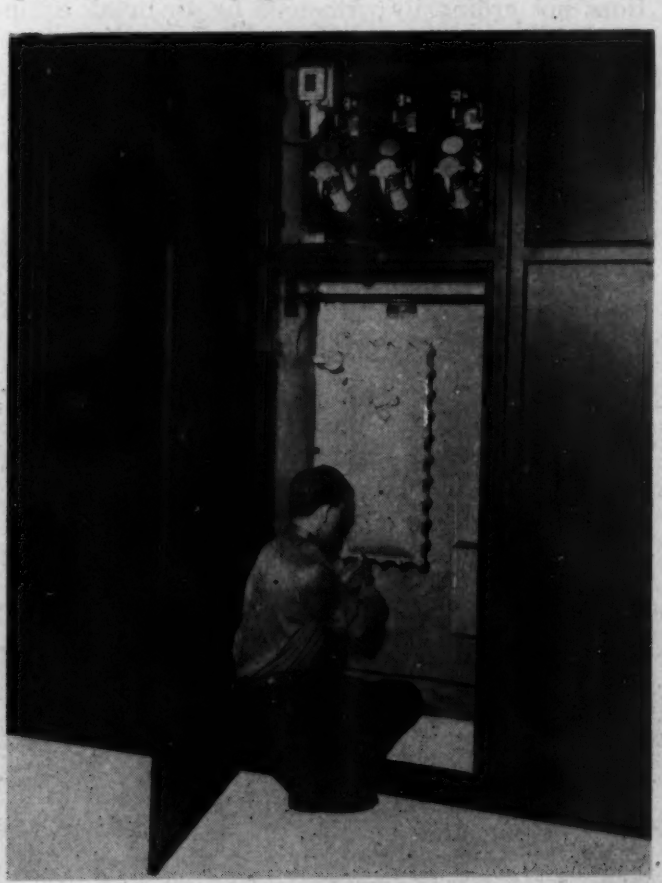


Figure 4—Semi-hazardous combination high-voltage starter for location in Class I, Division 2 area. Note explosion-proof limit switch on the disconnect's inclosing compartment and the explosion-proof inclosure containing control transformer disconnect and under-voltage relays.

in the hazardous area. Several manufacturers do, however, offer somewhat larger control apparatus built in accordance with their interpretation of the requirements. It should be recognized that there is both a practical and an economical limit to the size of equipment which can be made explosion-proof. When that limit is reached, or exceeded, it is generally safer and cheaper to install the apparatus outside of the area or in specially built control rooms.

Today most manufacturers offer low-voltage (600 volts or less) lines of air-break, explosion-proof control as follows:

(1) Across-the-line a-c full voltage starters and combination starters.

(2) One, two, and three-button push-button stations, and selector switches.

(3) Limit switches of most widely used types.

(4) Small pole-changing switches, reversing switches, and manual motor starting switches.

(5) A few of the smaller d-c reduced voltage starters, and where the demand warrants, such accessories as rheostats.

(6) In addition to the above, there are several manufacturers of conduit products who have made available inclosures for contactors, relays, meters, transfer switches, and a few less frequently used accessories.

Areas of Hazardous Gases

Some areas, particularly where hazardous gases are encountered, have associated corrosive conditions not ordinarily withstood by air-break equipment. For this type of application, the oil-immersed control equipment provides the answer (Figures 2 and 3). Low-voltage equipment now generally available for corrosive conditions is listed below:

(1) A-c full voltage and reduced voltage starters and combination starters.

(2) Push-buttons.

(3) Oil-immersed circuit breakers.

In general, there is no high-voltage equipment which can be made completely explosion-proof. Therefore, it is recommended that such equipment be kept out of Class I or II, Division 1 areas, as defined in the 1947 National Electric Code.

Manufacturers and users for some years have recognized the fact that some locations are normally free from hazard, although under certain abnormal conditions a dangerous condition may exist. The 1947 Code now recognizes such "semi-hazardous" locations and defines them as Class I, Division 2 areas or Class II, Division 2 areas. Straight explosion-proof low-voltage apparatus is furnished for the Division 2 type of hazard. Class I, Division 2 high voltage equipment is furnished as a combination of general purpose, oil-immersed high voltage starters coupled with completely explosion-proof accessories such as door interlocks, control circuit disconnect switches, and such other apparatus as is required to prevent the appearance of an electrical spark under normal operating conditions (Figures 4 and 5).

It is felt, in general, that it is best not to install so-called "semi-hazardous" equipment in any location which is frequently or normally hazardous. While on the surface it may appear that removal of arcing equipment from the area may be expensive, the consideration of over-all safety and the possible consequences should an explosion occur, cannot be ignored.

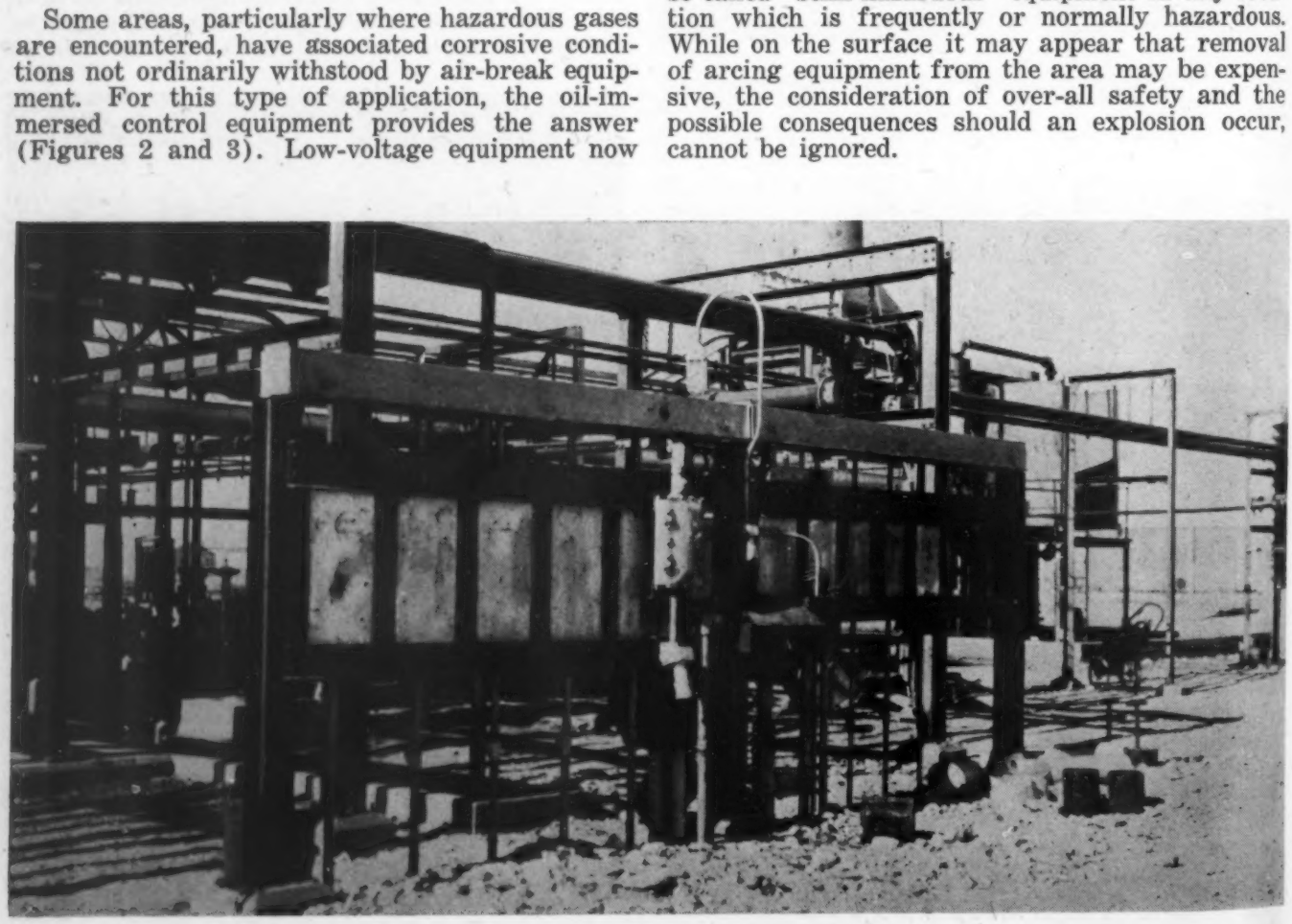
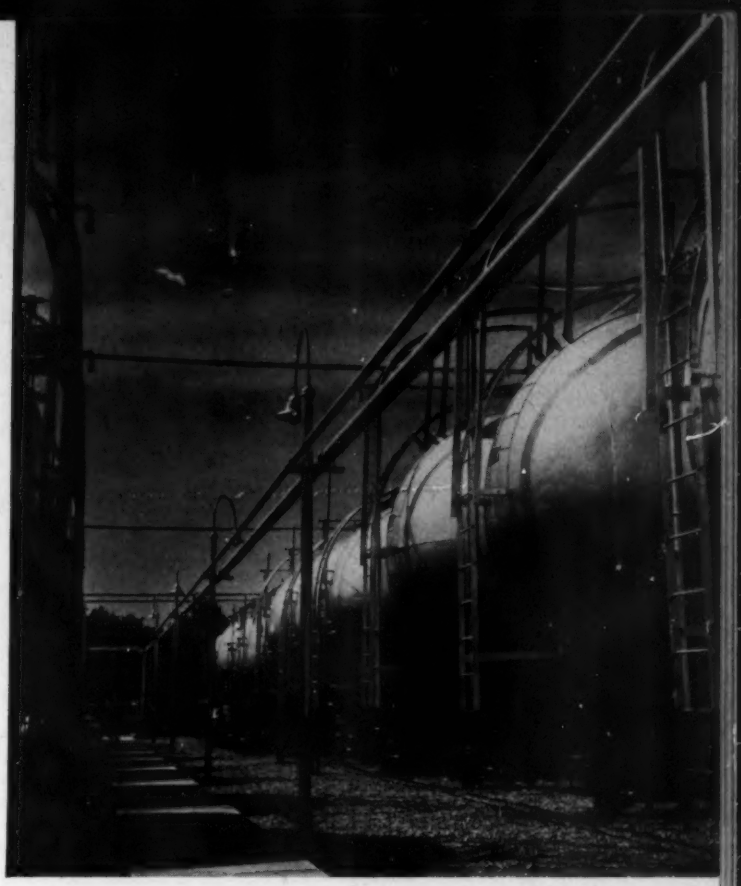


Figure 5—Refinery-type load distribution center for Class II, Division 2 location

Factors in the Future Of the LP-Gas Industry

WILLIAM F. LOWE

Secretary-Treasurer, Natural Gasoline Association of America



An example of the extensive installations at a butane and propane storage depot is shown above. The gases are pumped through pipe lines from the plant and are stored under great pressure. Photo was made at Warren Petroleum Corporation's plant at Salem, Ill.

MANY papers have been written about the future of the liquefied petroleum-gas industry in recent years. Correlating the predictions, it is evident that the industry has a future which merits the envy of other business.

The bibliography attached to this discussion lists those papers and where they can be found. They present all material currently known, or published, by some of the best authorities in the country, and are worth serious study. It is interesting to note, however, that some of these authorities did not hold the same opinions a few years ago. A review of the past may make some of the things in the future a little more understandable. At least, it will emphasize some of the unexpectedness of today's enormous demand for LPG.

Only three years ago there was considerable pessimism about the postwar outlook. At the NGAA convention in 1944 there was presented a symposium entitled "The Future of the LP-Gas Industry"[1] and those invited to take part were highly qualified to have opinions. The questions were submitted a month before the convention so that the answers were well considered. The first question presented was "Will the supply of propane, butane and mixtures increase or decrease in the immediate postwar period and, after four or five years of peacetime?" All agreed there would be a plentiful supply of all products in the first year of peace and that this condition would continue for three or four years unless the chemical plants began competing with fuel markets for the products.

We all know now that this answer was somewhat in error. However, the predictions are interesting in that they reveal no anticipation of the huge demand two years after the war. The question of chemical industry competition for products seems to have been justified because the volume of products going to these plants is now more than 22 percent of the total marketed.[2] The demand from this source has doubled since the prediction was made though the 325 million gallons used by this industry in 1946 could hardly account for the supply squeeze today. We are told on competent authority that this use will increase slowly but continuously though there is some doubt that the chemical industry can continue to buy much butane as raw material at current market prices.

WITH new uses being found daily for liquefied petroleum gases, and with improved methods in manufacturing and handling of the products, the LPG industry must plan to build more and more storage facilities to meet the public demand. Although the transportation problem (shortage of tank cars) is acute, this problem is only temporary; however, the writer urges that storage facilities in areas near distribution be built to meet the increased demands, and predicts propane will be more in demand than ever before. All photos courtesy Phillips Petroleum Company except one above by Warren Petroleum Corporation.

LPG Postwar Demand

Another question was on the demand for LPG products within two years after the end of hostilities. This question was broken down into the various types of consumers: domestic, industrial, utility, chemical, internal combustion engines, and refinery blending in motor fuel. Opinion was unanimous that there would be a considerable increase in domestic demand once adequate transportation facilities and appliances became available. It was also stated that deliveries of propane in this market would rise rapidly thus it would tend to replace much of the butane formerly used.

This answer shows some real forehanded thinking and the only error was on the side of conservatism in the size of the increases. It is reasonable to assume they did not expect the domestic market to jump from 445,617,000 gallons in 1944 to 763 million in 1946, an increase of 71 percent. The anticipated increase in the use of propane in the domestic market was based on some sound reasoning and some obvious economics. Basically, butane is currently worth more in other markets than it is when sold for cooking. It is only natural then, that the manufacturer should try to sell

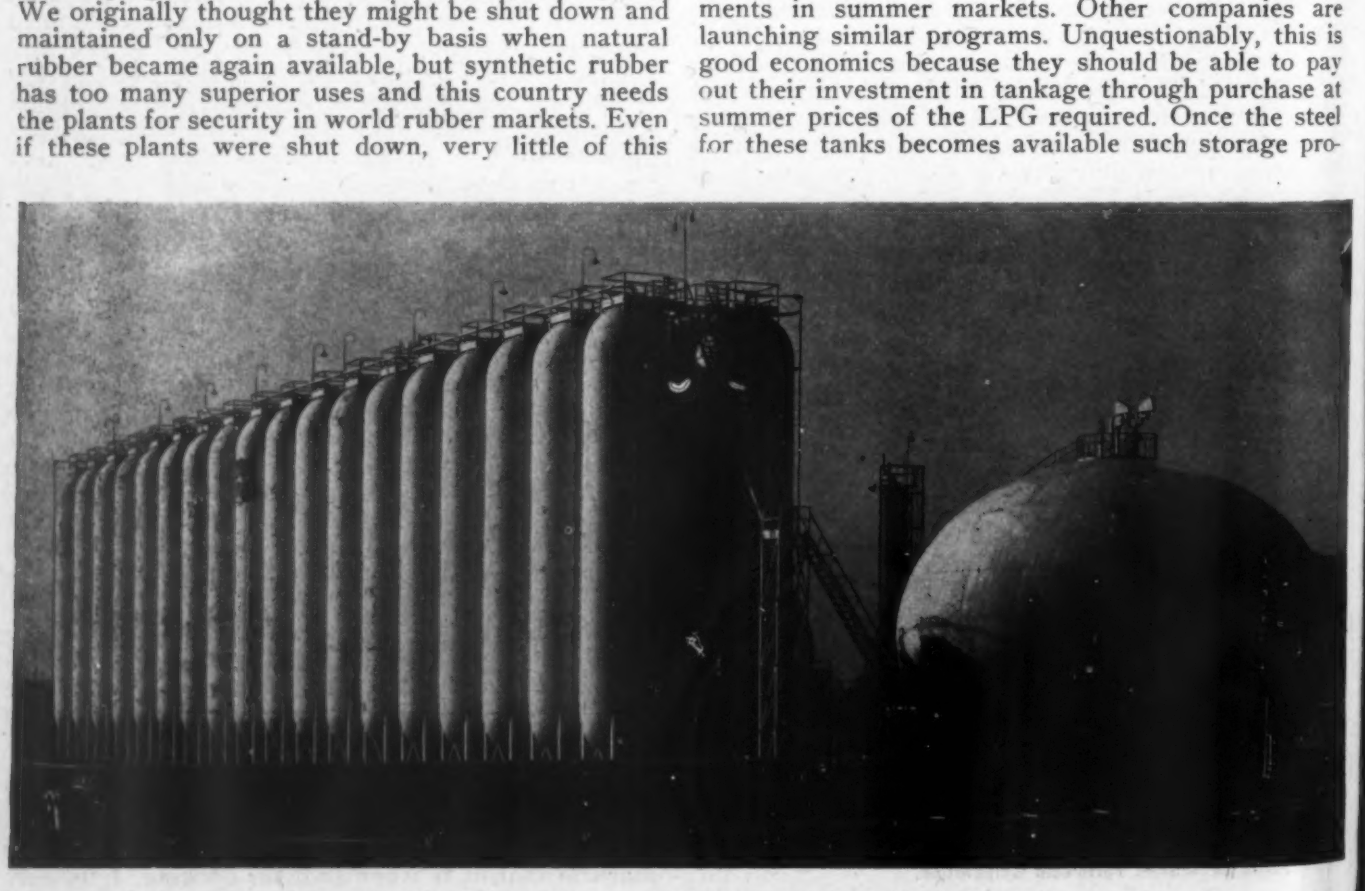
it in those markets giving the greatest return when he has another products, propane, which will serve even better as a fuel and which has been something of a problem to market anyway. The subject of propane manufacture and distribution is another story and will be discussed briefly in another portion of this paper. However, let us review the question of butane value and uses since it is a significant one in the future of the LPG industry.

Until recent years most of the LPG marketed was largely butane. The reason for this, too, was mostly economic. There was plenty of it, its low vapor pressure made it easy to handle in low cost, low-pressure containers and the market for it was relatively limited. Only a few marketing companies had begun the shift to high propane content in their LPG mixtures prior to 1941 and very few were advocating or making the change from low-pressure to high-pressure containers at that time. Then, as with so many other industries, the pressing demands of war brought radical changes in processes, created new markets for old products which became the raw material for numerous new products. In 1942, butane sales represented 81 percent of the total increase in sales of all LP gases but by the end of 1943 the demands of war had reduced the percentage to 25 percent of the total increase.[3]

Motor Fuel Demand for Butane

One of the war-stimulated uses for butane was in the manufacture of synthetic rubber which was using more than 300 million gallons of butanes and butylenes annually at the end of the war. There has been more than a 50 percent reduction in this volume though the industry will continue to use large quantities of butane because there are too many reasons for keeping some of these big rubber plants going. We originally thought they might be shut down and maintained only on a stand-by basis when natural rubber became again available, but synthetic rubber has too many superior uses and this country needs the plants for security in world rubber markets. Even if these plants were shut down, very little of this butane would return to the LPG market. It would go into the motor fuel market because most of it came from that source originally. This also applies to the butane which was used for making aviation gasoline during the war. Refiners who were making motor fuels less and less volatile by holding out butane for use in the manufacture of aviation gasoline, now have much of that supply restored to them but they still do not have enough butane to meet their demands. Also while the demand for aviation gasoline is but a fraction of war requirements, it is still many times the prewar demand and steadily growing.

One of the questions on which experts of three years ago had some difficulties was concerned with the use of LPG by public utilities. They really missed the boat on that one but certainly no one could have predicted the subsequent activities of John L. Lewis which probably had something to do with the building of new natural gas lines and the increased use of gas for industrial and community purposes. The experts thought there might be a decrease in these markets when the war ended. Instead of this result we find that sales to utilities in 1945 were 53,849,000 gallons and in 1946 they were 80 million gallons, an increase in one year of more than than 48 percent. According to the American Gas Association, LPG, as of May, 1947, was being delivered through mains to 187,000 consumers in 306 communities by 157 companies in 36 states. These figures were compared with those at the end of 1945 and showed 40 new public utilities had entered the field and 66 new communities were being serviced. This market has its peak load in winter but there is one factor which may be helpful for those principally interested in markets beyond the mains. Some utility companies have already built huge LPG storage so they can buy at least half of their winter requirements in summer markets. Other companies are launching similar programs. Unquestionably, this is good economics because they should be able to pay out their investment in tankage through purchase at summer prices of the LPG required. Once the steel for these tanks becomes available such storage pro-



Battery of liquefied petroleum gas vertical storage tanks at pipe line terminal.

grams are sure to proceed and this should ease some of the pressure on winter gas markets.

There are some other things to be said about the storage of LPG for future use. The manufacturer of these products is frequently faced with the question "Why can't I buy LPG in winter time?" and the answer supplied by Elmer Schmidt,[4] vice president, Lone Star Producing Company, Dallas, is the best on record: "Because you don't buy it in summer."

We on the manufacturing end of the business worry about the slim market in summer just as much as you do on the marketing end and we are trying to build markets for the summer months. We will find some, too, but it is foolish for both of us to reach the frantic stage every winter when we try to stretch the thin supply to hold the markets we have already built. The summer storage already built or building at plants is big but it will never be adequate to take care of winter peak loads. Distributors and consumers must build storage too. It does not make sense to me that a distributor should pay for *our* storage tanks when he could just as well build some of his own. It may not occur to him that he does this but every time he buys a gallon from a manufacturere's stored winter supply, he makes a small contribution to the cost of those tanks. He might better be writing off the cost of his own tanks through savings made in summer purchases of gas to fill them. If a high percentage of distributors and at least some consumers could be induced to do this it would ease the pressure on all of us. Another thing more to the point is that it would make available considerable quantities of LPG, which for lack of summer storage in the field, are being put back into the ground in re-pressuring or cycling programs or burned in oil field flares or under plant boilers.[5] These products would have been very welcome in the market last winter and they will be needed this winter too.

This battery of tanks belongs to a Mid-Western vitreous enameling and pottery works and holds LPG products which are used in the firm's manufacturing process.

Another argument for more storage at all points of the industry is the limitation of facilities for transporting the huge quantities of products during winter peaks. This is not just a temporary situation due to lack of tank cars now, but is likely to be a permanent one if the industry continues to grow on the same scale as in the past. The transportation problem may not again be as acute as it has been in the last two years but it can be a serious handicap in future winters if large local storage programs are not inaugurated soon.

Propane Production

Figures on the increase in production of propane are interesting. In less than five years the volume of propane marketed has risen from 25 percent of all LPG sold to nearly 45 percent. Current Bureau of Mines figures show that production is rising at a rapid rate. This increase is due to its increased market value, and natural gasoline plants are being rebuilt to obtain higher percentages. This reconstruction of a plant to raise the production of propane from 30 to 50 or 60 percent runs into money and can often mean an additional expenditure of half the cost of the original plant—in some cases $500,000 or more. A few modern plants recover 60 percent or more of the potentially available propane but older plants were not designed for the purpose. Both the natural gasoline and refining industries are fully aware of the need for greater propane recovery and they can see the favorable market for it. Refiners say there is about 2 percent of propane in most crude and if worth the effort of recovery it would make a substantial addition to available supplies. Here, then, is a growing and large source of LPG which has about all the stimulus it needs—that is, good economic reasons, for investing in more equipment to make this propane available.

The largest single market for butane is its use by refiners for the manufacture of motor fuel. Three years ago in the symposium there was some difference of opinion but in general all the experts seemed doubtful that there would be much increase in the use of light ends for this purpose because it was felt the refiner would have an excess of them due to his war-expanded processing facilities. There certainly was no reason at that time to question this conclusion. In fact, even two years later the matter was viewed with alarm[6] as it was noted that two war-stimulated refinery cracking processes yielded respectively 2.8 and 6.7 gallons of butanes in excess of the average motor fuel vapor pressure requirements. It was pointed out that more than 50 percent of the nation's postwar motor fuel supply would probably consist of this cracked material. Accordingly, the opinion was advanced there would be a potential surplus of butanes from *refinery sources alone,* during the next few years, which might average around 2 million gallons a day. This volume would be over and above the production of natural gasoline and cycling plants.

With all of the expert opinion that there would be less instead of more butane absorbed by the motor fuel market, one may well ask where the surplus is. The implication of that question would be that the men were wrong in their predictions but this would not be true. Except for one very unexpected factor, the unprecedented demand for motor fuel, there might well have been an excess of butane for the past year. When gasoline rationing was lifted, the

A gas manufacturing company uses propane to enrich the finished product. Huge tank at left holds manufactured gas; tubular tanks are storage for propane.

travel urge just "busted out all over" and there never has been such a demand for motor fuel.

In order to meet this demand, to increase the number of gallons available, refiners have had to use all the hydrocarbons they could get. In fact, the demand for many petroleum products was so great that the oil industry produced more hydrocarbons during the past year than it did during the peak of the war demand. So the refiner is not only using unexpected volumes of butane, but as the number of cars on the road increases, his demand will increase, unless there are radical changes in engine design and in the fuel requirements of these engines. Automotive engineers are predicting there will be 40 million passenger cars by 1960 and if that is true your parking problem could be as bad as your current butane supply problem.

The refiner also is being urged to increase his use of butane in motor-fuel blending for two reasons, one of which is conservation of natural resources and the other is concerned with engine performance. State conservation authorities[7] are contending the refiner should give greater consideration to utilization of light ends in his motor fuels if for no other reason than to conserve these valuable hydrocarbons. The Nowata road tests,[8] conducted this spring for the purpose of determining the vapor locking characteristics of 1942, 1946, and 1947 model cars, proved that in winter operation cold starting would be improved and the cars would not vapor lock on fuels of 15-pound vapor pressure. This is an increase of two pounds in the present maximum permissable winter vapor pressure for motor fuels and if this increase is made it will mean a potential market for 370 million gallons of additional butane.

The Nowata road tests were conducted by the NGAA and when the announcement was made that this huge volume of butane could be put in winter motor fuels without engine trouble, the first reaction was a surprising lack of enthusiasm among the member companies. Ten years ago then a similar road test series was sponsored, the results were greeted with real acclaim because at that time the marketing of light ends was something of a problem. This year, however, the problem is reversed and everyone asked where we would get the butane to supply the new demand if it developed.

There are two factors in this use of butane for motor fuel blending which probably make you of the LPG marketing end of the business cringe. One is the enormous volume involved and the other is that the greatest use would be in winter during your own peak demand. One comforting thought is that some of the increases cited are potential and not immediate, and they may never develop.

A natural question here would be whether butane was always going to be used in such quantities for motor fuel, and the answer right now seems to be affirmative but there is a little potential optimism in that quarter. Currently the volume of butane used in motor fuel blending is about twice the total volume of all LPG used in the LPG industry. According to Benz[9] this quantity of butane is potentially available to the industry if the consumers are willing to pay more for the product than it is worth in the motor fuel market. Present economics do not warrant this but future conditions might change to place the LPG industry in a more competitive position.

Some other factors in the motor fuel situation are accompanied by a number of large "ifs." For instance, if the automotive engine designer should turn from the present carburetor system of introducing motor fuel into engine cylinders to the diesel system of liquid fuel injection, there would be an immediate deemphasis of the octane number[10] and volatility requirements of the fuels used. Laboratory experiments[9] have proved that injection of fuels which bear little resemblance to those now used in automotive engines will give an operating efficiency at 10 to 1 compression ratio which compares favorably with normal engine operation at 7-1 compression ratio. There is no prediction that this engine is in the immediate offing but it is being seriously considered by research men and if experiments prove it practical its wide use would release large quantities of butane for other uses.

There seems to be little question that the trend of compression ratios of all automotive engines is upward and one of the principle incentives is the increase in miles per gallon. In a paper before the Society of Automotive Engineers last June,[11] C. F. Kettering told of successful experiments with an engine of 12.5-1 compression ratio in which miles per gallon was increased 25-40 percent. At this time the fuels required for such an engine would have to be of 100 octane number or better and one argument against the manufacture of such fuels is that the extensive cracking processes required to make them actually reduces the number of gallons produced. This has raised the question as to whether the economy in engine consumption warrants the loss in gallons at refineries. It will be some time before such high compression ratios are put in stock model cars but the trend is in that direction. On the basis of our present knowledge, the effect of higher compression ratios will be to increase rather than decrease the use of butane by refiners and it could also lead to much broader use of pressure carburetion in which butane itself could be the fuel.

A potent force in this trend toward higher compression ratios and higher octane numbers is the increasing awareness of the necessity for conservation of all petroleum hydrocarbons, particularly in motor fuels which represent the largest volume. While the automotive engine of today is vastly superior to that

of 20 years ago, the improvements made have been in the interests of mechanical efficiency rather than in fuel economy. Both the petroleum and automotive industries realize we must now obtain more efficient use of the gallons available. The basic and highly significant research outlined by Mr. Kettering is quite evidently a move in this direction. Both industries are watching this research and it is reasonable to assume that it will lead to some simple but fundamental changes in engine design which will combine the operating efficiency of high compression ratios with fuels of relatively low octane number. If such a fortunate result was obtained it would bring about hydrocarbon conservation on an unprecedented scale, and those interested in the butane supply would have the pleasure of watching the curve of butane use by refiners turn sharply downward.

The future character of fuels and engines are among the most important factors in the future of the LPG industry. For the time being, however, there seems to be little possibility that the demands of this greater single market for butane products will diminish.

There is some real hope for increased supplies in another direction and this is from the manufacturers themselves and from some new processes which give sizeable yields. Estimates of the potential production of propane at refineries, natural gasoline and cycling plants, indicate it is considered to be several times greater than the total volume now being produced.[9] The increased cost of making even part of this great volume available has already been indicated and it does not now seem probable that economics will ever be favorable enough to warrant complete recovery. However, you can rest assured that the trend of production from these sources is definitely upward and that the production, at least from natural gasoline and cycling operations, may double in the next few years.

A new source of supply is in sight from two plants now being built to use adaptations of the Fischer-Tropsch process for the primary purpose of converting dry natural gas into motor fuels. These plants are unique in that they are the first commercial plants of their kind to be built anywhere and though they are said to cost in the neighborhood of $15 million each, they may well be the forerunners of several more. The original name of the process has been changed to "synthine," a derivation from the word "synthesis" which tells what the process really is, the building of desired heavier hydrocarbons from the remnants of lighter hydrocarbons. In the course of the process a number of other products are produced, among which are liquefied petroleum gases. Since there is no data on commercial production, the actual volume of LPG which may be produced at these two plants is estimated at from 50,000 to 80,000 gallons per day. Both figures represent quite respectable volumes and either would be quite welcome in the markets of these products. It will be at least a year before any of this production will be available.

The squeeze of supply may hit again this winter but, baring unusual circumstances, we should be "over the hump" on supply by this time next year. If all other businesses had as bright a future as the LPG industry there would be fewer worried business men in the country. About all one has to do from now on is to nurse his present customers along, don't get oversold, build some storage wherever possible, and avoid responsibility for any unsafe operation.

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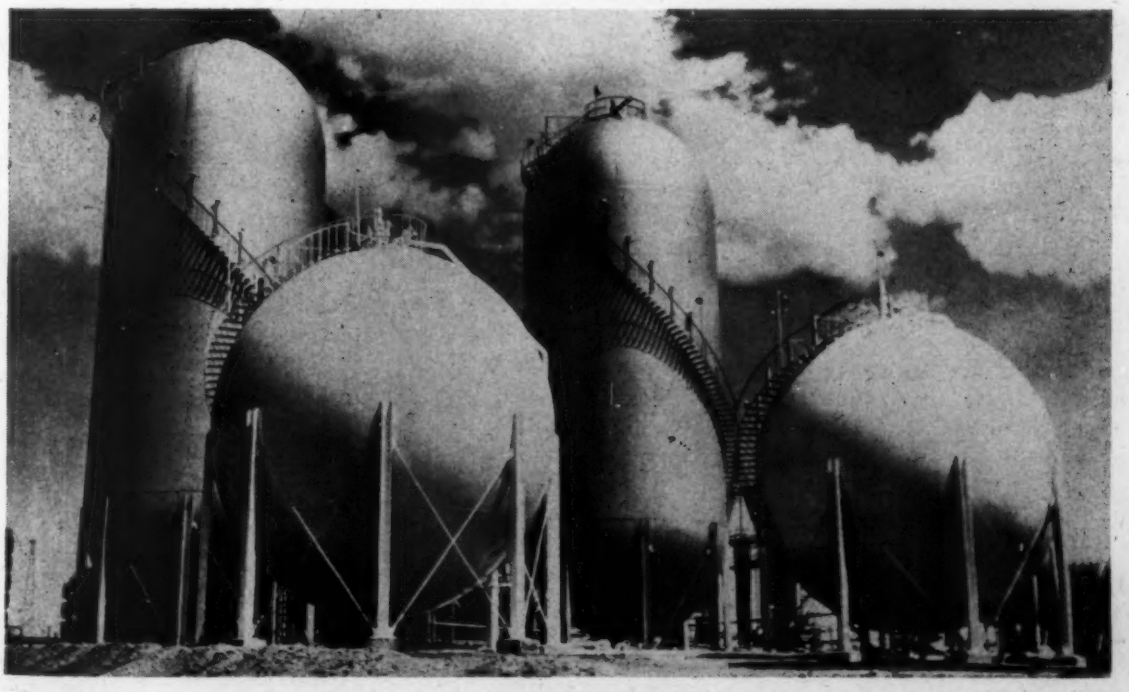


Large pressure storage tanks at liquefied petroleum gas manufacturing plant.

Flange Design Calculations

HARALD E. LONNGREN, Mechanical Engineer, New York

WHEN a designer faces the task of determining the thickness of an integral type flange and of calculating the various stresses in the flange, he has no means of telling what the ultimate stress distribution will be. That is, after his first guess of the probable flange thickness—as presently is necessary, he must, in most cases, correct his choice so as to obtain ultimate stresses which are permissible.

For a not too skilled designer this means a lot of work, particularly when it is a primary prerequisite that the flange be as economical as possible. This requirement is very pronounced for large diameter alloy flanges for high-temperature service.

The author presents here new formulas for determining the flange thickness quickly with an assurance of obtaining a predetermined and uniform stress distribution in the flange. The derivation of the new formulas is based upon the present formulas appearing in the ASME and ASME-API codes.

THE followinng analysis of the various stresses is based on a stress distribution equal to

$$\left.\begin{array}{l} S_H = n \times S_R \\ \end{array}\right. \quad \left.\begin{array}{l} n_{MIN} = 1 \\ n_{MAX} = 3 \end{array}\right\} \text{permissible by the codes}$$

A much preferred stress distribution is the following,

$$S_H = 1.5\, S_F$$

$$\frac{S_H + S_R}{2} = S_F$$

$$\frac{S_H + S_T}{2} = S_F$$

$$\frac{1.5\, S_F + S_R}{2} = S_F$$

$$S_R = .5\, S_F \therefore S_R = \frac{S_H}{3}$$

Thus $n = 3$

The following derivations emerge,

$$\frac{1}{n} \times \frac{M}{L} \times \frac{1}{g_1^2} = \frac{M}{L} \times \frac{\beta}{t^2}$$

$$\beta = \frac{t^2}{n g_1^2} \quad \text{or} \quad t = \sqrt{n g_1^2 \beta}$$

And

$$\frac{1}{n} \times \frac{M}{L} \times \frac{1}{g_1^2} = \frac{MY}{t^2} - Z \times \frac{1}{n} \times \frac{M}{L} \times \frac{1}{g_1^2}$$

$$t = \sqrt{\frac{n Y L g_1^2}{Z+1}}$$

Further

$$\sqrt{n g_1^2 \beta} = \sqrt{\frac{n Y L g_1^2}{Z+1}}$$

$$\beta = \frac{YL}{Z+1}$$

We know

$$L = \frac{M}{S_H g_1^2}$$

Thus by inserting

$$t = \sqrt{\frac{nYM}{SH(Z+1)}} = \sqrt{\frac{YM}{S_R (Z+1)}}$$

Identical results are also obtainable in the following manner,

$$\frac{MY}{t^2} - Z\frac{M}{L} \times \frac{1}{g_1^2} \times \frac{1}{n} = \frac{M}{L} \times \frac{1}{g_1^2} \times \frac{1}{n}$$

$$t = \sqrt{\frac{n\, Y\, L\, g_1^2}{Z+1}}$$

and also

$$\frac{MY}{t^2} - Z\frac{\beta \times S_H \times g_1^2}{t^2} = \frac{\beta \times S_H \times g_1^2}{t^2}$$

$$\beta = \frac{MY}{S_H g_1^2 (Z+1)}$$

Thus

$$\frac{t^2}{n g_1^2} = \frac{MY}{S_H g_1^2 (Z+1)}$$

$$t = \sqrt{\frac{nYM}{S_H (Z+1)}}$$

The sought for thickness of the flange can also be derived in the following manner:

$$\beta = \frac{t^2}{n g_1^2}$$

and

$$\beta = 1.33 \times \frac{F}{\sqrt{B_{go}}} \times t + 1$$

Thus,

$$\frac{1}{n g_1^2} \times t^2 = 1.33\, \frac{F}{\sqrt{B_{go}}} \times t + 1$$

$$t = \frac{n \times .665 \times F \times g_1^2}{\sqrt{B_{go}}} + \sqrt{\frac{\left(\frac{1.33\, n\, F g_1^2}{\sqrt{B_{go}}}\right)^2}{4} + n g_1^2}$$

It is to be noted that the flange thickness thus established represents the very thickness which will bring about the desired uniform stress distribution in a fully stressed tapered hub flange.

The maximum allowable total moment M can readily be established from equation,

$$M = \frac{t^2 S_H (Z+1)}{nY}$$

For an integral flange with a straight hub,

$$g_1 = g_o \text{ and } F = .9089$$

$$t = \frac{n \times .6044\, g_1^2}{\sqrt{B_{g1}}} + \sqrt{\frac{\left(\frac{1.2088 \times n \times g_1^2}{\sqrt{B g_1}}\right)^2}{4} + n g_1^2}$$

Conclusions

The primary object of this article is to introduce

new time-saving means of determining the thickness of an integral flange. The appended sample calculations are illustrative only and should not be construed in a broader sense. However, it might be well to point out that an ample value of g_1 will prove beneficial, particularly when the M_D moment is greater than the M_G moment. In general, a designer should strive to see to it that the hub correction factor f (per Figure 3) equals 1.0 whenever possible.

SAMPLE CALCULATIONS

Integral Flange—Tapered Hub

Code Method

$H_{GY} = 92.3 \times .25 \times 4500 = 103{,}825$
$H_{GP} = 92.3 \times .5 \times 2.5 \times = 23{,}650$
$H = 677.7 \times 205 = 138{,}950$
$W_{MIN} = \overline{165{,}600}$
$A_{BMIN} = 8.28$ sq. in.
$A_{BACT} = 11.73$ sq. in.
$W = 200{,}000$

$H_D = 572.6 \times 205 = 117{,}400$ $h_D = 1.625$ $M_D = 190{,}750$
$H_T = H - H_D = 21{,}550$ $h_T = 1.406$ $M_T = 30{,}300$
$H_G = W - H = 61{,}050$ $h_G = .8125$ $M_G = 49{,}550$
$M_o = 270{,}500$
$M = 10{,}000$

$K = A/B = 1.22$ $g_1/g_o = 3$ $d = 23.75$
$T = 1.83$ $h_o = \sqrt{27 \times .25} = 2.6$ $e = .257$
$Z = 5.1$ $h/h_o = 1.15$ $f = 1.0$
$Y = 9.89$ $F = .67$
$U = 10.87$ $V = .0745$

$t = 1\frac{3}{8}''$
$\alpha = 1.353$ $S_H = \dfrac{10{,}000}{.85 \times .563} = 20{,}850$
$\beta = 1.469$
$\gamma = .74$ $S_R = \dfrac{1.469 \times 10{,}000}{.85 \times 1.89} = 9500$
$\delta = .11$
$L = .85$ $S_T = \dfrac{10{,}000 \times 9.89}{1.89} - 5.1 \times 9500 = 3700$

$\dfrac{S_H + S_R}{2} = 15{,}175$ psi

NOMENCLATURE

S_H Longitudinal hub stress
S_R Radial flange stress
S_T Tangential flange stress
S_F Allowable flange stress
A Outside diameter of flange
B Inside diameter of flange
C Bolt circle diameter
G Mean diameter of gasket
R See flange sketch
g_1 Thickness of hub at back of flange
g_o Thickness of hub at small end

$h_D = R + \dfrac{g_1}{2}$

$h_T = \dfrac{1}{2}(R + g_1 + h_G)$

$h_G = \dfrac{1}{2}(C - B)$

t Thickness of flange
p Flange design pressure
m Gasket compression factor
y Gasket yield point
b Effective gasket yielding width
$H_{GY} = \pi \times G \times b \times y$
$H_{GP} = \pi \times G \times 2b \times m \times p$
$H = .785\ G^2 \times p$
W_{MIN} Minimum required bold load $= H_{GY}$ or $(H_{GP} + H)$
W_{ACT} = Actual bolt load
$W = \dfrac{W_{MIN} + W_{ACT}}{2}$ = Flange design bolt load
S_B Allowable bolt stress
A_{BMIN} Minimum bolt area
A_{BACT} Actual bolt area
$K = A/B$
T, Z, Y, U Per Figure 1
F, V Per Figure 2 for tapered hubs
h Hub length
$h_o = \sqrt{Bg_o}$ for tapered hubs; $h_o = \sqrt{Bg_1}$ for straight hubs

$e = \dfrac{F}{\sqrt{Bg_o}}$ for tapered hubs; $e = \dfrac{.9089}{\sqrt{Bg_1}}$ for straight hubs

$d = \dfrac{U}{V} h_o g_o^2$ for tapered hubs

$d = \dfrac{U}{.551} h_o g_1^2$ for straight hubs

f Hub stress correction factor per Figure 3

$\alpha = t \times \dfrac{F}{\sqrt{Bg_o}} + 1$ for tapered hubs

$\alpha = t \times \dfrac{.9089}{\sqrt{Bg_1}} + 1$ for straight hubs

$\beta = 1.33 \times t \times \dfrac{F}{\sqrt{Bg_o}} + 1$ for tapered hubs

$\beta = 1.33 \times t \times \dfrac{.9089}{\sqrt{Bg_1}} + 1$ for straight hubs

$\gamma = \dfrac{t \times \dfrac{F}{\sqrt{Bg_o}} + 1}{T}$ for tapered hubs

$\gamma = \dfrac{t \times \dfrac{.9089}{\sqrt{Bg_1}} + 1}{T}$ for straight hubs

$\delta = \dfrac{t^3 \times V}{U \sqrt{Bg_o} \times g_o^2}$ for tapered hubs

$\delta = \dfrac{t^3 \times .551}{U \sqrt{Bg_1} \times g_1^2}$ for straight hubs

$L = \dfrac{t \times \dfrac{F}{\sqrt{Bg_o}} + 1}{T} + \dfrac{t^3 \times V}{U \sqrt{Bg_o} \times g_o^2}$ for tapered hubs

$L = \dfrac{t \times \dfrac{.9089}{\sqrt{Bg_1}} + 1}{T} + \dfrac{t^3 \times .551}{U \sqrt{Bg_1} \times g_1^2}$ for straight hubs

$S_H = \dfrac{M}{L} \times \dfrac{1}{g_1^2}$

$S_R = \dfrac{M}{L} \times \dfrac{\beta}{t^2}$

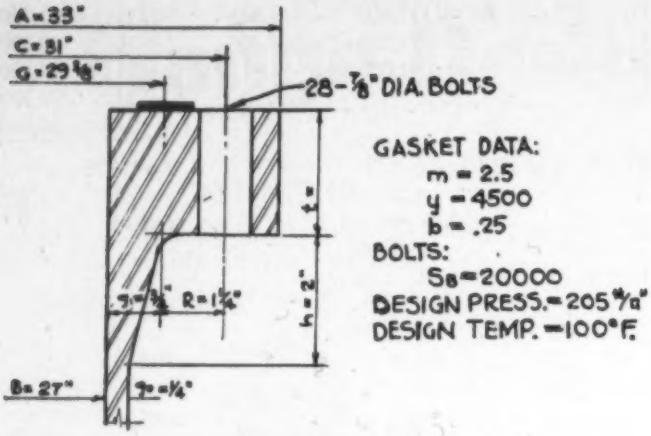
$S_T = \dfrac{MY}{t^2} - ZS_R$

} Code formulas for stresses in integral flanges

The moment M is determined, in the following manner

$H_D = .785\ B^2 \times p$
$H_T = H - H_D$
$H_G = W - H$

$M_D = H_D \times h_D$
$M_T = H_T \times h_T$
$M_G = H_G \times h_G$
$M_o = M_D + M_T + M_G$
$M = \dfrac{M_o}{B}$



Integral flange-tapered hub.

New Method:

Stress case: $S_H = 3S_R$

$$t = \frac{1.995\ Fg_1^2}{\sqrt{Bg_0}} + \sqrt{\left(\frac{3.99\ Fg_1^2}{\sqrt{Bg_0}}\right)^2 / 4 + 3g_1^2}$$

$$= \frac{1.995 \times .67 \times .563}{2.6} + \sqrt{\left(\frac{3.99 \times .67 \times .563}{2.6}\right)^2 / 4} + 3 \times .563$$

$t = 1.62$ inches

The stress distribution for the actual moment M at hand will be

$t = 1\frac{5}{8}$"

$\alpha = 1.4175$ $\quad S_H = \dfrac{10{,}000}{.954 \times .563} = 18{,}450$

$\beta = 1.555$

$\gamma = .774$ $\quad S_R = \dfrac{1.555 \times 10{,}000}{.954 \times 2.64} = 6150$

$\delta = .18$

$L = .954$ $\quad S_T = \dfrac{10{,}000 \times 9.89}{2.64} - 5.1 \times 6150 = 6150$

It will thus be seen that the flange is not fully stressed. This means that the actual total moment can be increased to

$$M = \frac{t^2 S_H (Z+1)}{3Y} = \frac{2.64 \times 22{,}500 \times 6.1}{3 \times 9.89} = 12{,}150$$

With this value for M, the stress distribution becomes as desired

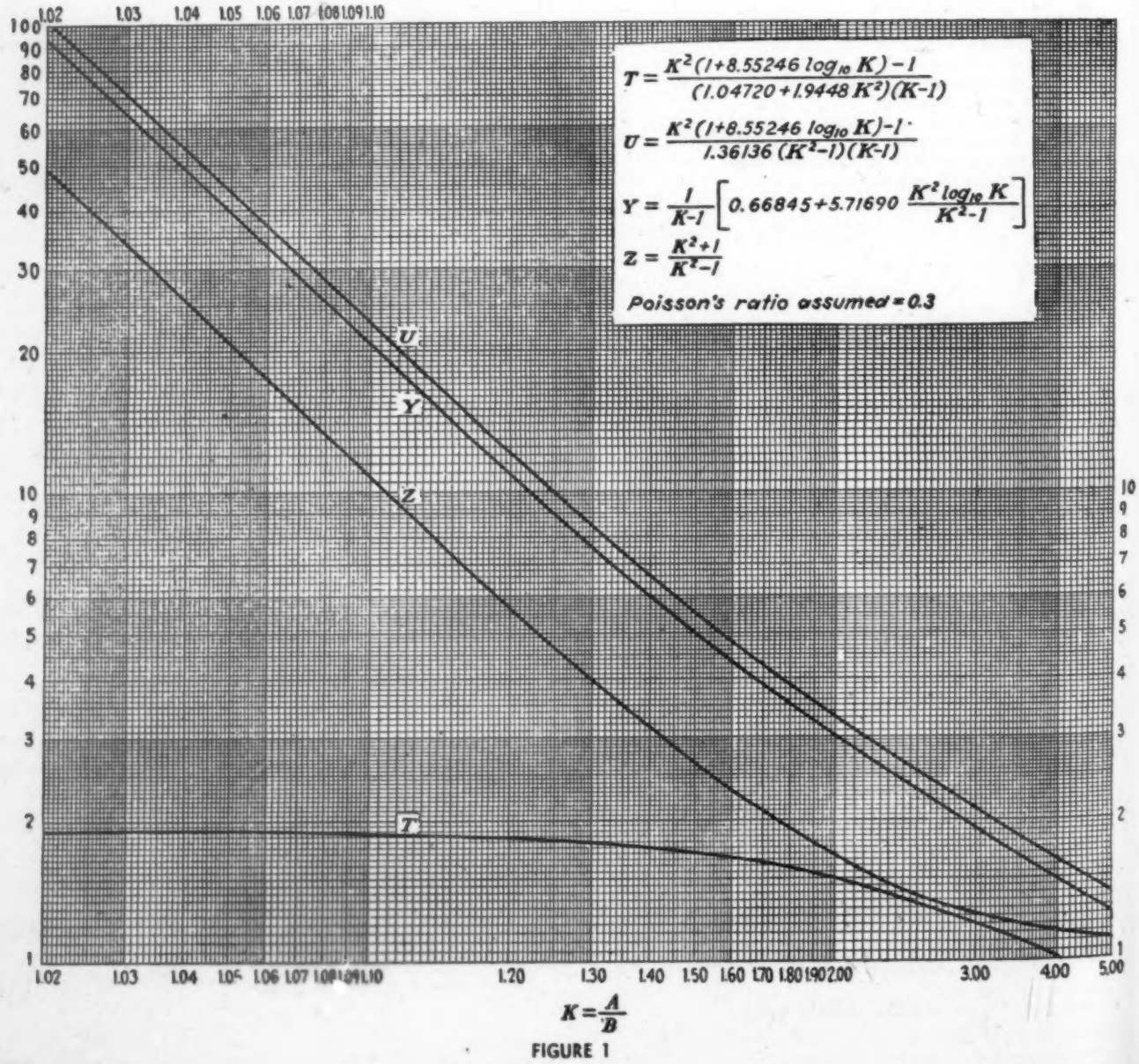


FIGURE 1

$$S_H = \frac{12{,}150}{.954 \times .563} = 22{,}500$$

$$S_R = \frac{1.555 \times 12{,}150}{.954 \times 2.64} = 7500$$

$$S_T = \frac{12{,}150 \times 9.89}{2.64} - 5.1 \times 7500 = 7500$$

Using the new formula

$$t = \sqrt{\frac{3YM}{S_H (Z+1)}}$$

$$t = \sqrt{\frac{3 \times 9.89 \times 10{,}000}{22{,}500 \times 6.1}} = 1.47 \text{ inches}$$

The stress distribution is,

$t = 1.47''$
$\alpha = 1.377$
$\beta = 1.502$
$\gamma = .752$

$$S_H = \frac{10{,}000}{.885 \times .563} = 20{,}000$$

$$S_R = \frac{1.502 \times 10{,}000}{.885 \times 2.16} = 7900$$

$\delta = .133$
$L = .885$

$$S_T = \frac{10{,}000 \times 9.89}{2.16} - 5.1 \times 7900 = 5500$$

Integral Flange Straight Hub

Code Method

$H_{GY} = 92.3 \times .25 \times 4500 = 103{,}825$

$H_{GP} = 92.3 \times .5 \times 2.5 \times 205 = 23{,}650$
$H = 677.7 \times 205 = 138{,}950$
$W_{MIN} = 165{,}600$

$A_{BMIN} = 8.28$ sq. in.
$A_{BACT} = 11.73$ sq. in.
$W = 200{,}000$

$H_D = 572.6 \times .205 = 117{,}400$ $h_D = 1.625$ $M_D = 190{,}750$
$H_T = H - H_D = 21{,}550$ $h_T = 1.406$ $M_T = 30{,}300$
$H_G = W - H = 61{,}050$ $h_G = .8125$ $M_G = 49{,}550$
$M_o = 270{,}506$
$M = 10{,}000$

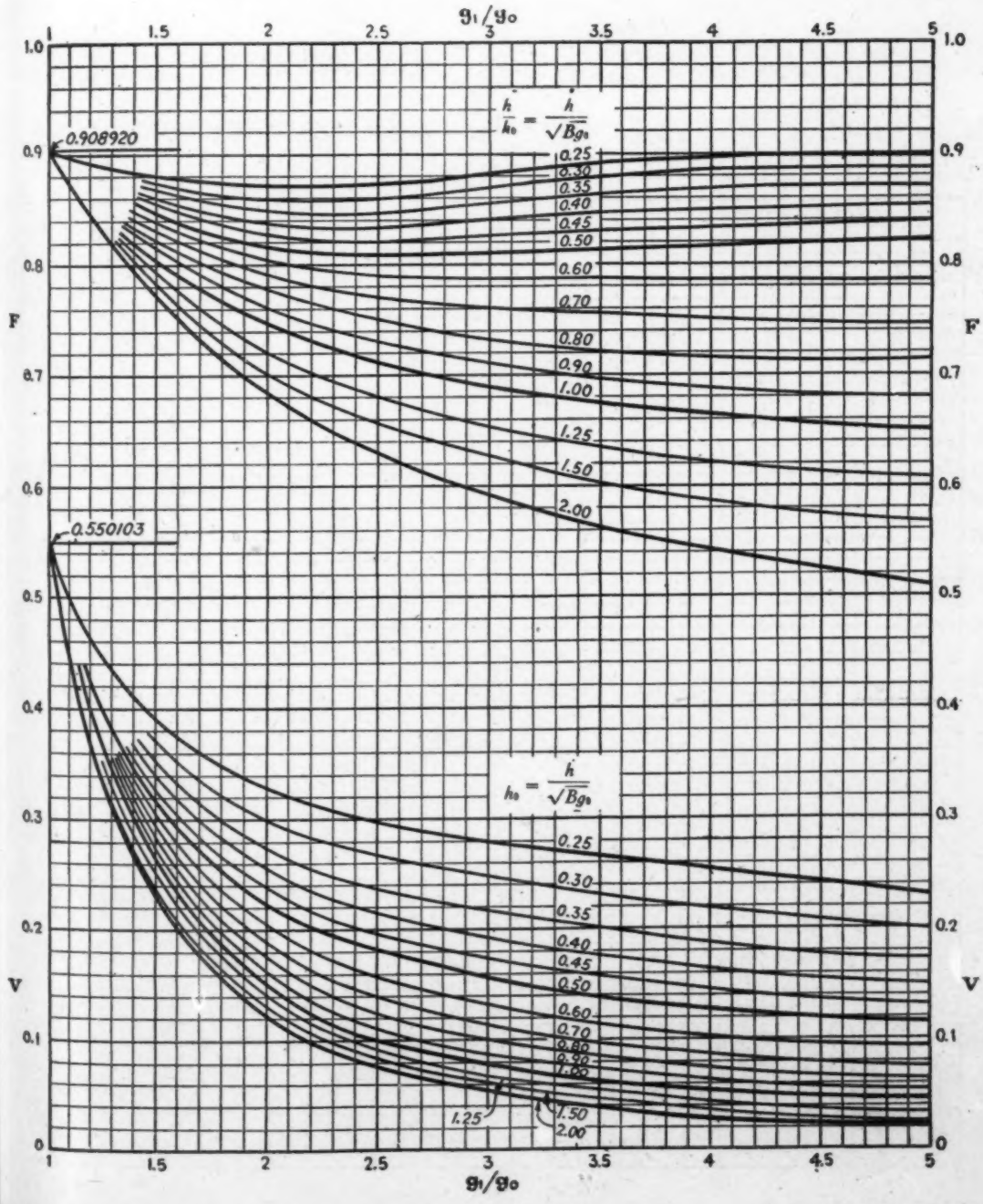
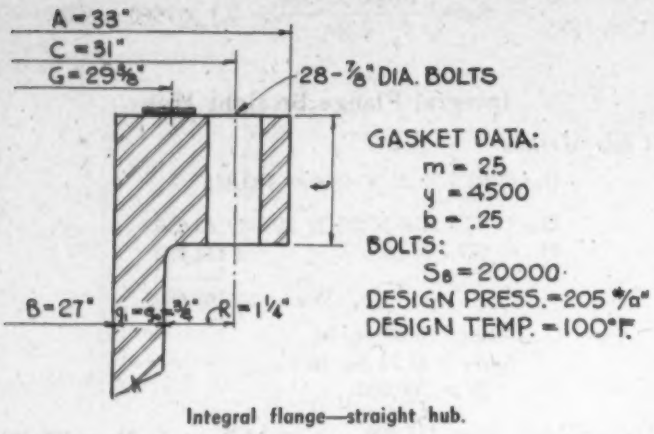


FIGURE 2

Acknowledgment

Charts in Figures 1, 2 and 3 are reproduced from the ASME-API code.



Integral flange—straight hub.

Code Method:

$K = A/B = 1.22$ $\quad g_1/g_0 = 1.0$

$T = 1.83$ $\quad h_0 = \sqrt{27 \times .75} = 4.5$ $\quad d = 50.0$

$Z = 5.1$ $\quad F = .9089$ $\quad e = .2$

$Y = 9.89$ $\quad V = .551$ $\quad f = 1.0$

$U = 10.87$

$t = 1\text{-}9/16''$ $\quad t^3 = 2.44$ $\quad t^3 = 3.815$

$\alpha = 1.312$ $\quad S_F = 15{,}000$

$\beta = 1.415$ $\quad S_H = \dfrac{10{,}000}{.793 \times .563} = 22{,}500$

$\gamma = .717$ $\quad S_R = \dfrac{1.415 \times 10{,}000}{.793 \times 2.44} = 7350$

$\delta = .076$ $\quad S_T = \dfrac{9.89 \times 10{,}000}{2.44} - 5.1 \times 7350 = 3500$

$L = .793$ $\quad \dfrac{S_H + S_R}{2} = 14{,}425$ psi

New Method

Stress case:

$S_H = 3S_R$

$$t = \frac{1.813 \times g_1^2}{\sqrt{Bg_1}} + \sqrt{\frac{\left(\frac{3.626 g_1^2}{\sqrt{Bg_1}}\right)^2}{4} + 3g_1^2}$$

$$t = \frac{1.813 \times .563}{4.5} + \sqrt{\frac{\left(\frac{3.626 \times .563}{4.5}\right)^2}{4} + 3 \times .563}$$

$t = 1.545''$ (for uniform stress distribution).

The stress distribution for the actual moment M at hand will be,

$t = 1\text{-}9/16''$

$\alpha = 1.312$ $\quad S_H = \dfrac{10{,}000}{.793 \times .563} = 22{,}500$

$\beta = 1.415$

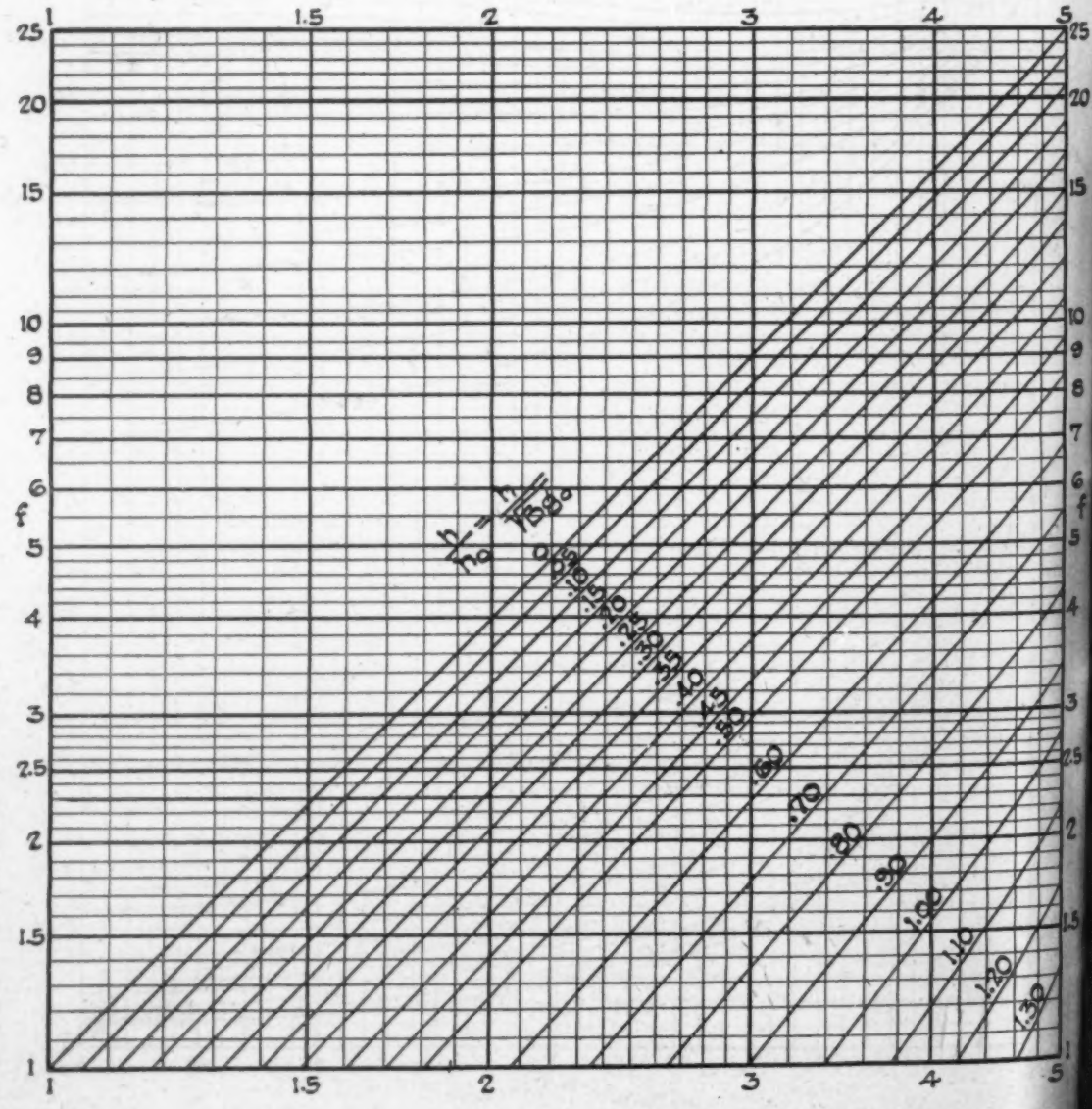
$\gamma = .717$ $\quad S_R = \dfrac{1.415 \times 10{,}000}{.793 \times 2.44} = 7350$

$\delta = .076$

$L = .793$ $\quad S_T = \dfrac{9.89 \times 10{,}000}{2.44} - 5.1 \times 7350 = 3500$

It will thus be seen that the flange is fully stressed.

FIGURE 3



The author has prepared a second article titled "Flange Design Considerations" which will appear in an early issue of THE REFINER. *It will disclose a new and graphical method of finding the actual stress ditribution in a flange which has been strengthened because of added material to compensate for expected corrosion or erosion.*

Two Million Monthly—

The Steel-Barrel Industry

STEEL barrels, or drums, as they are commonly called, are a major requirement of the oil industry, approximately 80 percent of the 2 million manufactured monthly in the United States being used to ship oils, greases and gasoline.

The first steel barrel was made in 1900. In 1902 the first bilge-shaped steel barrel was patented, the research having been conducted by a petroleum producer. The first barrels were riveted and later were hand welded. In 1900 one man could weld about 16 barrels an hour. Today one machine welds 300 an hour.

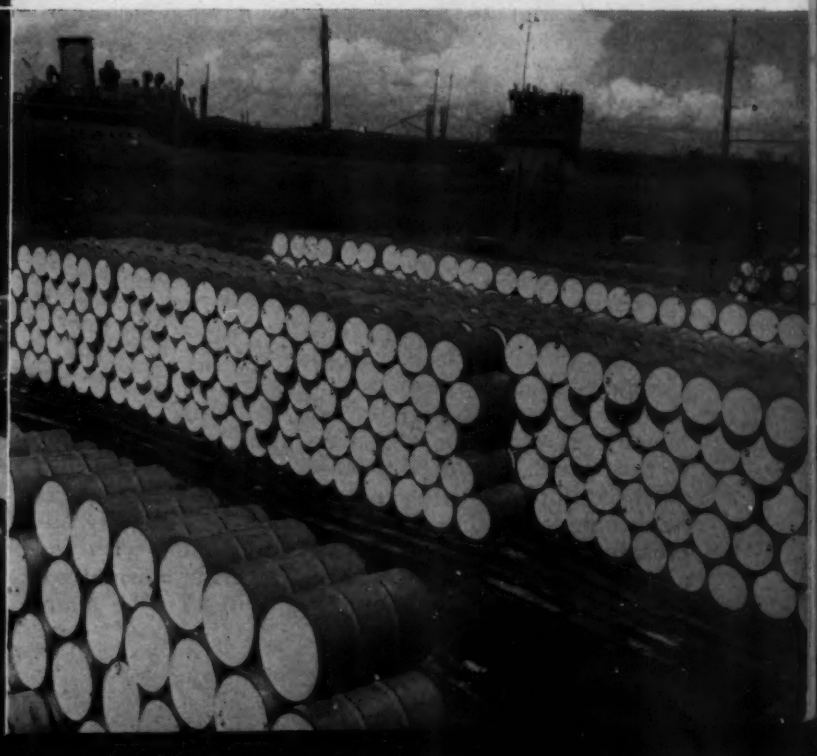
Photos herewith were made at the Beaumont, Texas, plant of a subsidiary of United States Steel Corporation, which in 1943 formed U. S. Steel Products Company out of the old Petroleum Iron Works Company and its Petroleum Iron Works division at Beaumont and Port Arthur.

At left, the first step in steel-barrel manufacture, steel sheets are being rolled into cylindrical form preparatory to flash welding the side seam. The rolled plates are shown moving down the assembly line in the background for further processing.

Above, the formed and welded drum shells, with heads and bottoms assembled, are being placed in a double seamer where they are joined to the shell to form a leak-proof connection.

Lower left, the welded side seams of these 100-pound capacity drums are being tested for leaks.

Lower, right, loaded steel drums in the shipping yards of a major refinery in Texas preparatory to being put aboard ship for transport.



Chemicals From Petroleum

E. R. SMOLEY, R. M. TORREY, and L. KNIEL
The Lummus Company, New York

WHEN we heard Dr. Smoley talking on the subject of chemicals to be manufactured from petroleum, as part of an open panel discussion at an American Chemical Society meeting recently held in Lafayette, La., it was evident that the talk could furnish the basis of an excellent article for *Petroleum Refiner*. His talk was made from notes prepared with the cooperation of R. M. Torrey and L. Kniel. These notes have now been reviewed and somewhat extended by the authors to produce the present paper, which outlines current petro-chemical activities and discusses some comparative economics.

THE production of synthetic chemicals from petroleum has been rapidly expanding since the early 1930's. From an output of 150,000 pounds of petroleum chemicals (not including aromatics) in 1925, the total production increased to almost four billion pounds in 1946.[1] In the solvents field petroleum and natural gas are source materials for 5 percent of this country's methanol production, 50 percent of ethanol, 100 percent of isopropyl alcohol, 75 percent of acetone, 35 percent of n-butyl alcohol, 90 percent of amyl alcohol, major part of xylenes and a large part of acetic anhydride.[2] The main reasons for the increasing use of petroleum as a raw material are its economy and abundance, as well as the continuing occurrence of shortages of many of the other previously used source materials.

This trend continued during the war although there were shifts in product consumption from civilian to war uses. There was also a tremendous expansion in the production of many new war synthetics, such as butadiene, styrene, toluene, cumene, aviation alkylate, plastics and solvents.

About 475,000 tons of butadiene were produced in 1946. Six hundred thousand tons of toluene from petroleum and 15,000 barrels per day of isopropyl benzene (cumene) for rich mixture blending in aviation gasoline were produced in 1944.

Ethyl Alcohol Now Critical

Current shortages of older raw materials for synthetics have affected the production of many chemicals such as ethyl alcohol, phthalic anhydride, glycerine and benzene.[3] With increasing prices for grain and shortage of molasses supply, ethyl alcohol has become a critical chemical. This is being relieved by its production in increasing quantities from ethylene obtained from cracking petroleum. Methyl alcohol produced from natural gas, and isopropyl and normal propyl alcohol from petroleum are also helping by substituting for many ethyl alcohol uses. Ortho-xylene, produced from petroleum, is now being used to supplement the inadequate supply of coal tar naphthalene in the manufacture of the rapidly increasing production of phthalic anhydride, with use as a plasticizer in alkyd resins. Glycerine, normally a by-product of soap manufacture, will soon be made commercially in Houston, from propylene and chlorine. Glycerine has many uses, one being the production of alkyd resins. Another coal tar source material which is falling short of demands is benzene. Sold at 13 cents per gallon in 1937 to 1945, it was quoted at 19 cents per gallon this July and is expected to level off at 23-25 cents per gallon. It does not seem so long ago when coal tar benzene was used in quantities for its anti-knock properties in motor gasoline. The reverse is now close at hand. It now appears that the industry will eventually produce benzene from petroleum for its conversion to styrene, phenol, aniline, chlorobenzene, solvents, nylon, detergents, and insecticides.

The lighter hydrocarbons from petroleum and natural gas are the most widely used in the production of chemicals. The olefins are very reactive and are available from petroleum and natural gas in large volumes. Ethylene, propylene, and butylenes find large application in the manufacture of plastics, rubber, and resin products. The production of ethylene and propylene, roughly in equal proportions, exceeded one billion pounds in 1945, indicating the large part played by these source materials in the production of synthetic organic chemicals.

The production of synthetic detergents made from petroleum has now grown from practically nothing before the war to 250 million pounds per year with an estimated 400 million pounds to be manufactured next year. They compete at equal price with soap but show advantages in sudsing in hard water with no scum and with higher wetting power.

The application in the United States of the Fischer-

Tropsch reaction for the production of gasoline, diesel oil, alcohols, and other oxygenated chemicals from natural gas will cause an enormous increase in synthetic production when the two large plants now under construction—one at Brownsville, Texas, and the other at Hugoton, Kansas—commence operation probably in 1950. These plants are each expected to produce about 5000 barrels per day of gasoline, about 2000 barrels per day of diesel fuel, and a tremendous volume of oxygenated hydrocarbon synthetics as by-products.

In conjunction with these plants will be built chemical separation plants for the recovery and purification of the by-product chemicals as well as for the production of esters and higher alcohols. The estimates of the synthetic organic chemicals which are expected to be produced from the Brownsville plant (see table opposite) indicate the large volume of available petroleum chemicals.[4] The Hugoton installation is expected to be capable of producing quantities of chemicals in the same order of magnitude.

Many of these chemicals have never been produced in large quantities but it is expected that uses for them in the industry will develop. The impact of this production of chemicals such as acetone, methanol, methyl ethyl ketone, ethanol, and normal propyl alcohol is the subject of much discussion, but since the chemicals production plants will not be completed for many years, it is believed that the increasing demands for most of these materials will tend to offset over-production. The actual production of purified chemicals from the above list of chemicals and quantities available will be governed by supply and demand and the economics involved and will be prepared for the market to meet demands.

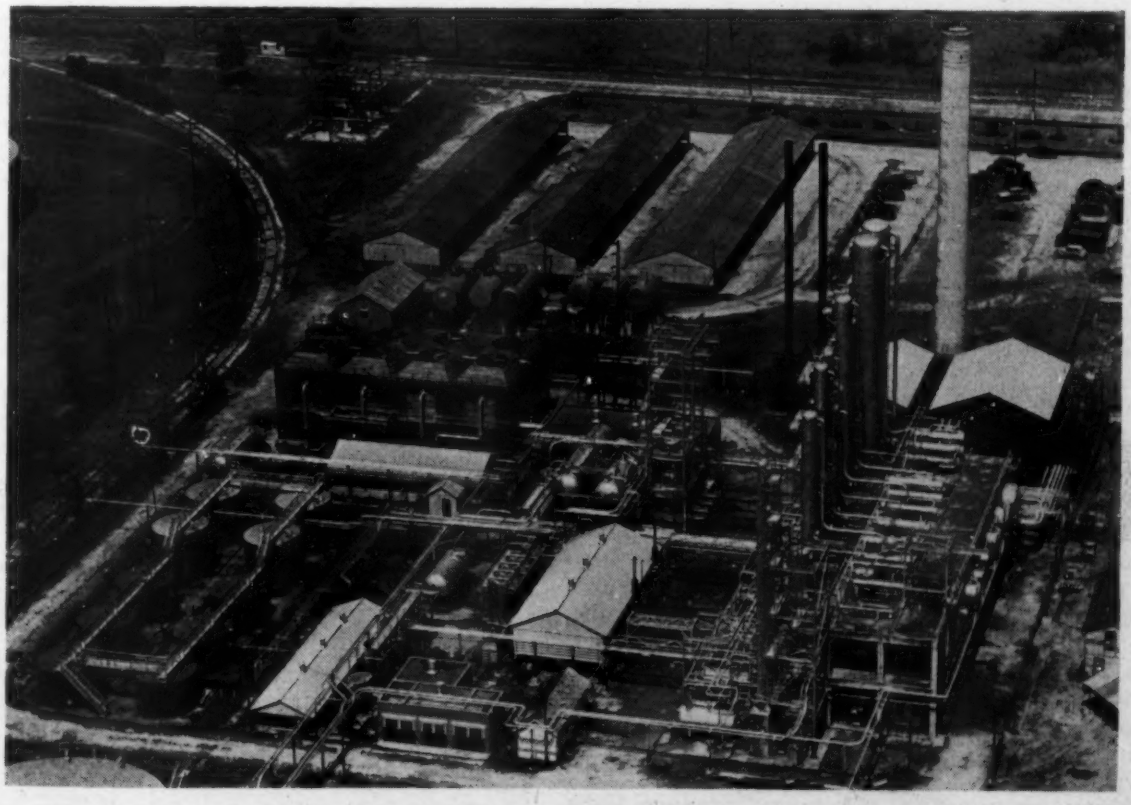
In these Fischer-Tropsch plants as well as in many other plants for the production of synthetic chemicals from petroleum and natural gas many of the process techniques, well known to the oil refining industry, are finding excellent application. The process units for the production of the intermediate source materials from petroleum such as ethylene and propylene are very similar to petroleum refining plants. These process techniques are discussed more fully below.

Estimated Production of Chemicals From One Hydrocol Plant

PRODUCT	Lbs. per Year
Methanol	730,000
Ethanol	63,680,000
n-Propyl alcohol	14,400,000
n-Butyl alochol	4,370,000
n-Amyl alcohol	1,060,000
Total	84,240,000
Acetaldehyde	9,100,000
Propionaldehyde	1,930,000
n-Butyraldehyde	2,750,000
Total	13,780,000
Acetic acid	24,700,000
Propionic acid	8,700,000
n-Butyric acid	4,200,000
Total	37,600,000
Acetone	11,200,000
Methyl ethyl ketone	4,780,000
Methyl n-Butyl ketone	250,000
Methyl propyl ketone	600,000
Total	16,830,000
Grand Total	152,450,000

New Ethylene Plants

Many new plants for the production of ethylene are now under construction or being projected which will continue to increase production over the next five years. The following currently reported list of ethylene producing plants and their estimated daily production serves to illustrate the importance of this intermediate. The plants listed are those which manu-



Two-thousand Barrel Daily Aviation Alkylation Plant

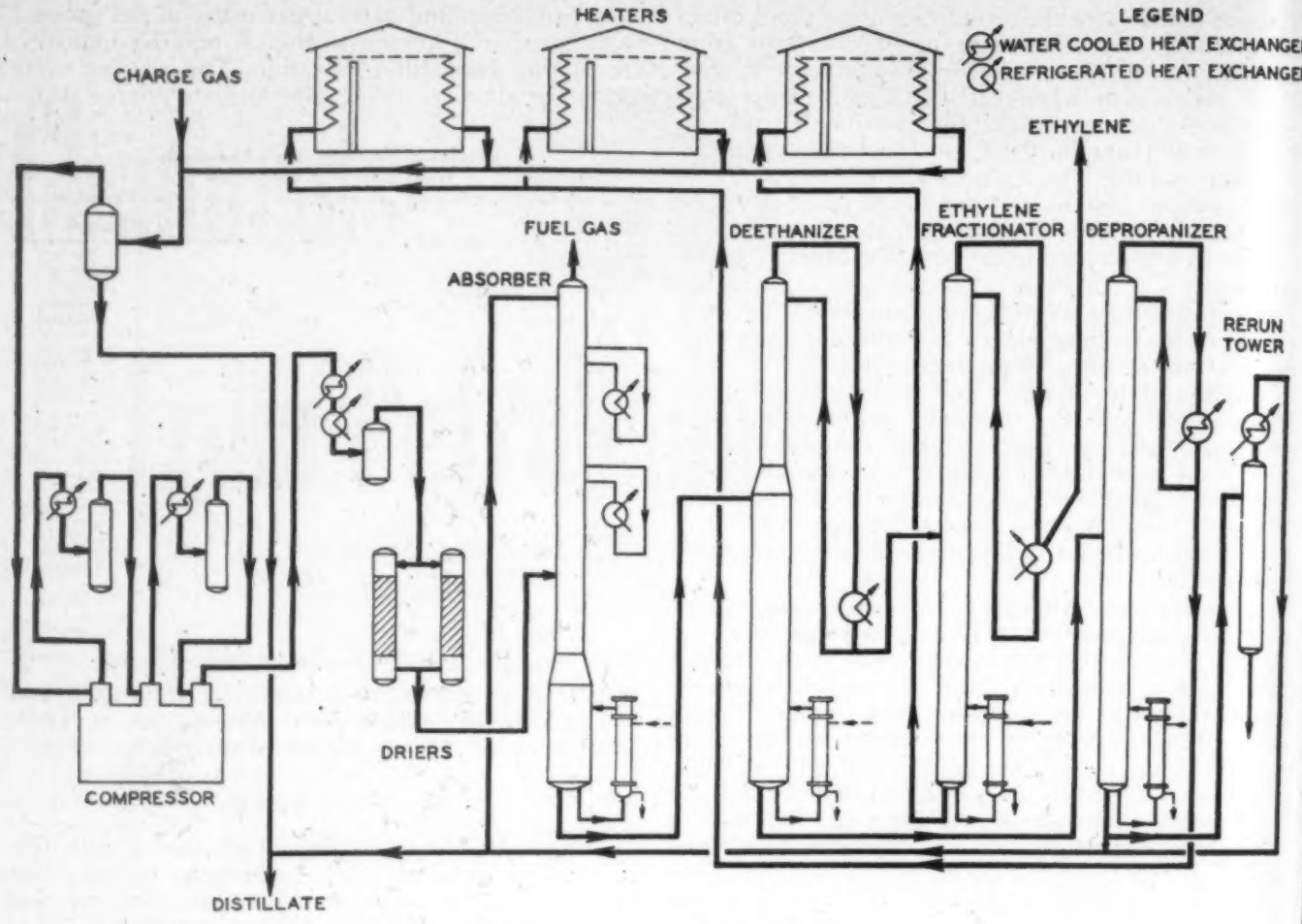


Figure 1. Lummus Ethylene Unit

facture ethylene from petroleum and natural gas constituents; alcohol dehydration plants have not been included.

PLANT AND LOCATION	Approximate Production of Ethylene Pounds Per Day
1. Carbide & Carbon, South Charleston / Whiting / Texas City, Texas	900,000
2. Dow Chemical Company, Midland, Michigan	150,000
3. Dow Chemical Company, Vleasco, Texas	80,000
4. du Pont, Orange, Texas	150,000*
5. Ethyl Corporation, Baton Rouge, La.	50,000
6. Ethyl Corporation, Baton Rouge, La.	150,000*
7. Jefferson Chemical Co., Port Neches, Texas	175,000*
8. Koppers Co., Kobuta, Pa.	40,000
9. Monsanto Chemical Co., Texas City, Texas	175,000
10. Shell Chemical Co., Houston, Texas	325,000*
11. Southern California Gas Co., Los Angeles, Cal.	800,000**
12. Standard Oil Co. of Louisiana, Baton Rouge, La.	275,000
13. Other producers	100,000
Total	3,170,000

* Under construction.
** Shut down recently.

For the production of ethylene the petroleum industry offers as raw materials refinery off gases containing propane and ethane and the respective olefins, also propane and ethane from natural gasoline and cycling plants, and liquid stocks such as naphthas, gas oils and reduced crudes. Composite refinery off gases, while they vary depending on the types of operation carried out in the refinery, will show an approximate composition in mol and weight percent is shown in the table at right.

Cracking operations in a refinery produce light hydrocarbon paraffins and olefins, and catalytic cracking produces more olefins than thermal cracking. The extent to which these operations are carried out in a refinery therefore influence the percentages of ethylene, propylene and ethane, propane in a refinery off gas. The ethylene in the off gas is recovered along with ethylene which is produced by cracking ethane and propane. The cracking operations for the production of ethylene from ethane, propane and heavy oils are carried out at low pressure and high temperature with relatively short furnace residence time. Typical ultimate yields of ethylene from ethane, propane and gas oil in weight percent are 75, 48 and 25-32 respectively. At approximately 45 percent conversion per pass, propane yields 16.7 weight percent of ethylene and 15.8 weight percent of propylene once through. The yield of propylene once through thermal cracking of heavy oils varies from 6 to 16 weight percent. Propylene may also be produced by catalytic dehydrogenation of propane with ultimate yields of over 90 weight percent. Some early production of ethylene employed multiple recuperative checker brick furnaces for

Approximate Composition of Refinery Off Gases

	Mol. Percent	Weight Percent
Impurities	4.0	3.2
Hydrogen	1.0	0.1
Methane	9.0	4.1
Ethylene	5.0	3.8
Ethane	25.0	21.1
Propylene	9.0	10.5
Propane	46.0	55.6
Butanes	1.0	1.6
Total	100.0	100.0

cracking heavy gas oils or reduced crudes. One of these furnaces was heated up to white heat by the combustion of fuel, steam was then passed through the checker brick thereby being preheated to 2000° F. Charge oil was then blended with the steam and the operation continued until the temperature dropped to 1500° F. when this operation was switched to another furnace. The first furnace was then reheated and the cycle repeated.

Tubular furnaces have been employed for the cracking of ethane, propane, naphthas and gasoil stocks. More recently heavy stocks have been cracked at high conversions per pass in a continuous moving bed of inert material in an attempt to overcome the difficulties resulting from coke formation in tubular furnaces with these types of stock. The results have been promising and a yield comparison of moving bed cracking vs. tubular cracking on a paraffinic gas-oil of about 650° F. end point in weight percent follows:

	Moving Bed	Steam Tubular
Temperature	1382	1350
Hydrogen	1.2	0.4
Methane	11.0	8.0
Ethane	0.4	5.3
Ethylene	25.0	14.7
Propane	0.7	1.0
Propylene	12.5	15.2
All C_4 Fractions	7.5	10.6
Distillate & Fuel Oil	41.0	44.0
Coke	0.0	0.0
Totals	99.3	99.2

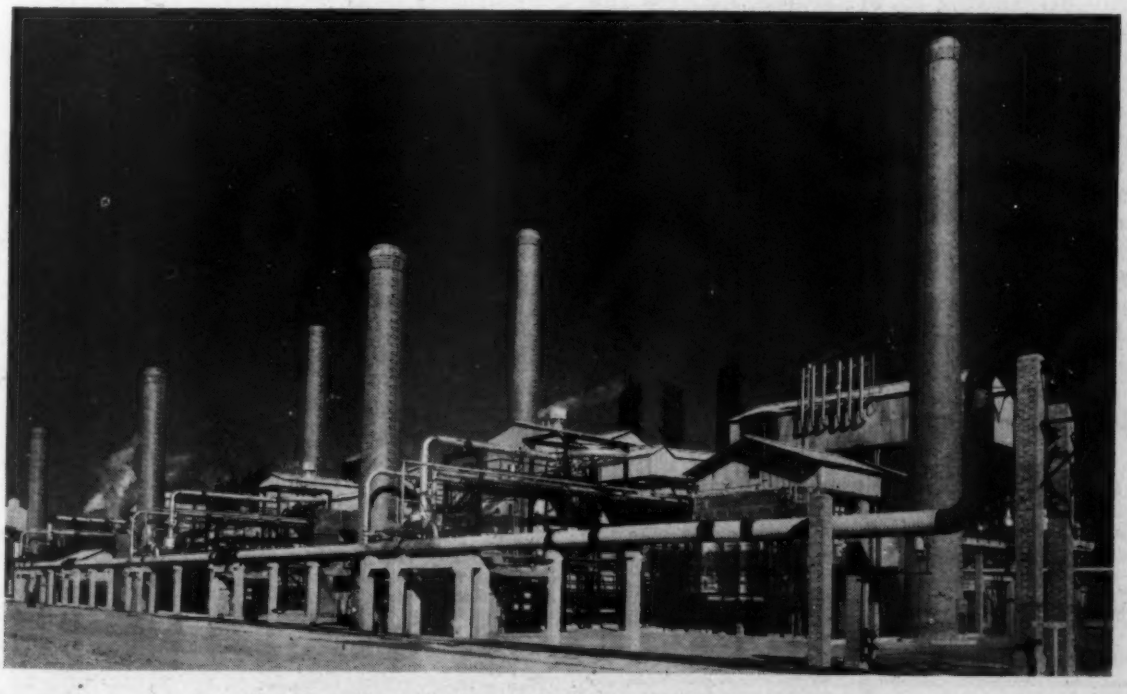
Stocks have also been cracked successfully for ethylene and propylene by direct contact with molten lead.

Ethylene Separation and Purification

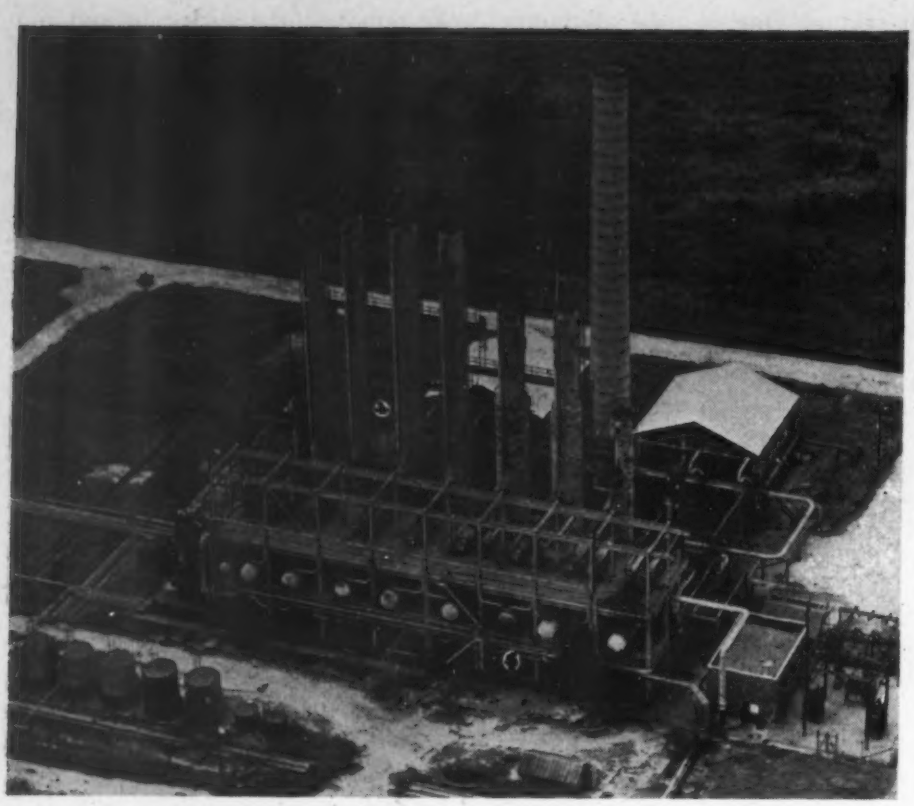
The problem of separation and purification of ethylene from charge stock and furnace effluents has been handled in several ways. Absorption, low temperature fractionation, and charcoal adsorption are the tools which are being used for this purpose. Their economic application depends on the concentration of the component to be removed, the purity desired and general process considerations. The furnace effluent stream is generally quenched by direct contact with water and then compressed to the operating pressure of the first processing tower. Flow sheet (Figure 1)[5] shows the process flow of a modern ethylene plant charging refinery gas. The first tower, whether a low temperature fractionation tower, an absorber, or a charcoal adsorber, serves to remove the methane and lighter as overhead fuel gas was with a minimum loss of ethylene. The ethane and heavier fractions are then sent to an ethylene tower operating at low temperature which removes ethylene product overhead. When propylene is not removed as a product, the ethane, propane and propylene are then cracked for the ultimate production of ethylene. In the method shown in Figure 1, the ethane and heavier bottoms are processed in a de-ethanizer which removes an overhead of ethane plus ethylene. This overhead is then charged to an ethylene fractionator where product ethylene is removed overhead. The ethane bottoms is selective charge stock to ethane cracking furnaces. The bottoms from the de-ethanizer are charged to a depropanizer taking overhead propane and propylene as furnace charge to propane furnaces. The bottoms from the depropanizer are rerun to furnish aromatic distillate by-product, which is also used as an absorbing medium when an absorber is used on the furnace effluent gas to remove methanes and lighter.[6] When propylene is required as product, the overhead stream from the depropanizer can be separated and purified to 80-85 percent purity by straight fractionation at high reflux ratios or to higher purities by either extractive or azeotropic distillation or charcoal adsorption.

Recycle Operation

The thermal production of ethylene and the thermal or catalytic production of propylene is almost always carried out as a recycle operation to obtain optimum yields of products. The selection of proper recycle ratios in the design and operation of a particular plant is of considerable importance in view of the



Butadiene Plant Capable of Producing 150,000 Tons Annually



Azeotropic Distillation Hydrogen Grade Toluene Plant

problem of purification. It is influenced by economic considerations such as the yield loss or gain at various recycle ratios and the expense of manufacture at different plant capacities.

Investment and operating costs of an ethylene plant are primarily dependent on 1 the plant capacity and 2) the cost of charging stock and utilities, particularly fuel. To illustrate, an ethylene plant for the production of 100,000 pounds per day of ethylene, using an average composite refinery off-gas as charging stock, will at today's prices cost approximately $2.5 million. Doubling the production figure would increase the investment to $4 million, i.e., by $1.5 million. Another 100,000 pounds increase would only cost $1.25 million additional, or just one-half as much in capital investment as the first 100,000 pounds per day of production. For a plant producing 100,000 pounds of ethylene per day from a refinery off gas with heavy fuel worth 3 cents per gollon, the net manufacturing cost per pound of ethylene is 3.5 cents. This figure reduces to 2.9 cents for a plant of 200,000 pounds daily capacity and to 2.7 cents for the 300,000 pounds per day plant. The respective figures with heavy fuel oil worth only 1 cent per gallon are 2.5, 2.0 and 1.9 cents per pound of ethylene.

With gaseous charge stock and fuel oil at 1 cent per gallon, the components of total manufacturing cost of ethylene are as follows:

Breakdown of Ethylene Manufacturing Cost
(In Cents Per Pound)

PLANT CAPACITY, LBS./DAY	100,000	300,000
Fixed Charges	1.4	0.9
Direct Operating Expense	0.8	0.7
Net Cost of Charge Stock	0.3	0.3
Total Mfg. Cost	2.5	1.9

These figures include a nominal allowance for yard construction outside of battery limits, for steam generating facilities, cooling tower and cooling water pumping plant, but no storage for either charging stock or finished products. It also does not include loading or unloading facilities, which in many instances are not required, as the processing units are usually located close to the ethylene producing unit.

If propylene is recovered in approximately equal quantity with the ethylene, the total plant investments increase approximately by 25 percent, but on the basis of equal value of propylene and ethylene, the unit manufacturing cost of either is reduced by approximately 30 percent.

The manufacturing costs of products from ethylene further reflect the advisability of large capacity plants for minimum cost of product. Ethylene is converted into ethylene oxide in one processing scheme by the use of chlorine and lime and may be further processed for the production of ethylene glycol by the use of weak sulfuric acid as catalyst, and concentration by distillation. If we assume off refinery gases at 1 cent per therm (100,000 Btu), chlorine at 1.75 cents per pound and lime at $8.00 per ton, a 30,000 pound per day ethylene plant would show a production cost for ethylene of 4 cents per pound, ethylene oxide 10.3 cents per pound, and ethylene glycol 74 cents per gallon, while a plant which produces 100,000 pounds of ethylene per day would show respectively 2.5 cents, 9.2 cents and 58 cents for the three products. The approximate investments of these two plants for the manufacture of ethylene glycol including utilities are 2.3 million and 4.0 million dollars respectively.

Another important factor bearing on the economics of these products is the availability of various petroleum raw materials for the production of ethylene. Current price levels of the liquefied petroleum gas market are depriving ethylene plants of increasing amounts of propane charge stock. It is possible that in the near future propane for ethylene manufacture will become scarce resulting in greater dependence on ethane. In many cases it may be necessary to resort to the selection of heavier stocks in spite of the fact that investment and operating costs will increase. For the present the expansion in naural gasoline plant operations is making available larger quantities of propane and ethane. In the long range future the Fischer-Tropsch process using natural gas and later coal will be a factor in the supply and demand of ethylene and petroleum chemicals.

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Maintenance of Pressure Gauges

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Wilmington, California

THIS paper deals with the practical aspects of maintenance for pressure gauges in an oil refinery. The authors state that the proper maintenance of pressure gauges begins with proper selection, standardization, and proper installation and these points are discussed first. Actual details of repairing and testing gauges are not included.

The maintenance of pressure gauges is incidental to the primary task of the measurement of pressure. It must be kept in mind that adequate maintenance is not merely repairing and testing gauges in a shop, but is fundamentally required to allow an operator to measure pressure accurately and conveniently at all points in his plant, an absolute necessity for safe and efficient operation.

This paper was recently presented by the Southern California Meter Association as part of a course in instrumentation.

THREE questions should be answered before anyone repairs, reads, or works with pressure gauges.

What is pressure? The term "pressure" as we use it refers to fluid force per unit area and is called pounds per square inch (psi). By "fluid" we mean liquids, gases, or vapors. Pressure is created by the compression of a fluid. The energy stored in the fluid by the compression causes the particles (that is molecules) to bombard the walls of the vessel or the inside of the pressure gauge. The amount of bombardment or pressure is measured by instruments called pressure gauges.

Why do we measure pressure? The proper and safe control of fluids in vessels and the control of flow in pipe lines necessitates using pressure gauges for control. Other types of control are temperature, liquid level, rate, and composition (by laboratory tests).

How do we measure pressure? A simple Bourdon tube is the most common method of measuring pressure. Most devices for measuring pressure are based upon the principle that a curved metallic tube changes shape (tends to straighten out—so as to equal the forces on all walls), when the pressure within the tube becomes greater than the pressure outside of the tube.

This straightening out effect is transmitted to gears through a link mechanism and is made to indicate on a scale or record on a chart.

Other types of mechanical devices for the measurement of pressure are the helical tube, the spiral tube, the diaphragm, and the bellows.

The manometer which is a "U" tube containing a liquid is perhaps the oldest and simplest method of measuring pressure, but is not in the scope of this paper and will not be discussed.

The indicating pressure gauge is so common; so taken for granted, and so simple in operation that its importance is often overlooked.

This refinery has approximately 3400 indicating gauges of the 4½-, 5- and 6-inch size; approximately 400 regular instrument board mounted gauges. This does not include recording gauges or all of the 2½ inch-0-30 psi gauges used in connection with air transmission instruments and on diaphragm motor valves.

The measurement of pressure is a very important function of any instrument department, and methods of testing, repairing, and maintaining pressure gauges is essential.

Proper Selection and Standardization

Each instrument board mounted gauge must necessarily be considered as an individual problem and the following notes do not necessarily apply.

Flush mounted gauges of the 6 or 8-inch size are usually selected for board mounting. The range and make considered individually from a standpoint of symmetry, ease of reading, etc.

For the run of the mill numerous indicating gauges

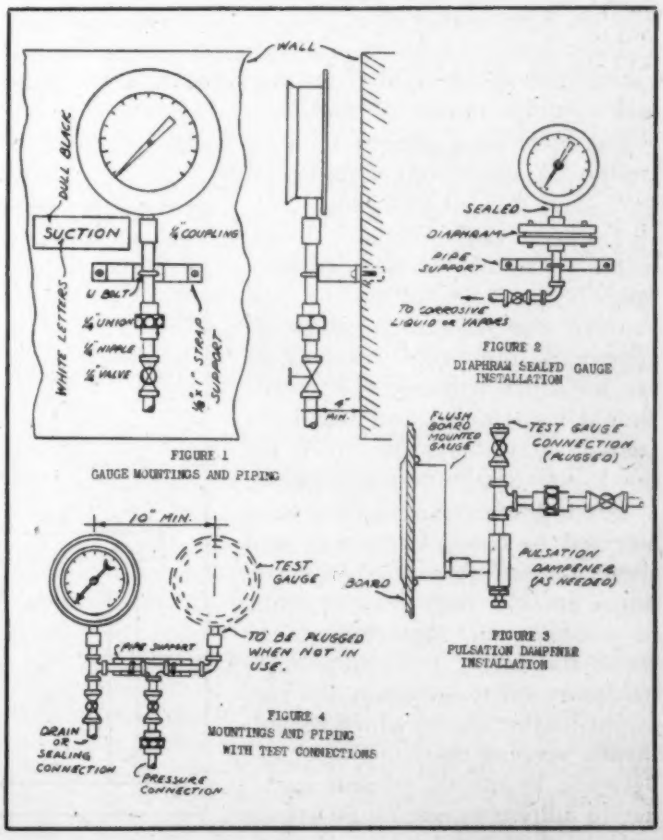


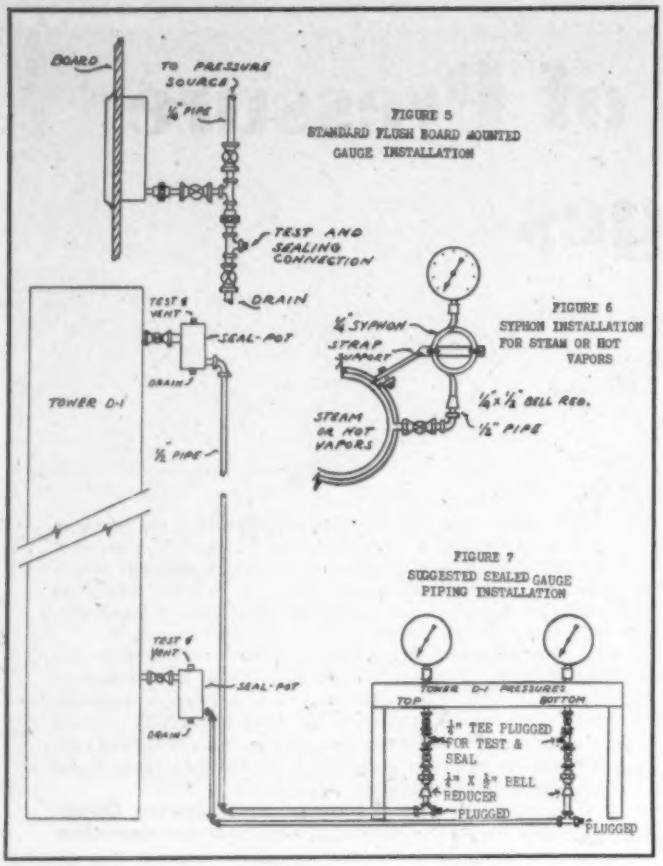
FIGURE 1
GAUGE MOUNTINGS AND PIPING

FIGURE 2
DIAPHRAM SEALED GAUGE INSTALLATION

FIGURE 3
PULSATION DAMPENER INSTALLATION

FIGURE 4
MOUNTINGS AND PIPING WITH TEST CONNECTIONS

Sketch No. 1—Suggested Pressure Gauge Installation.



Sketch No. 2—Suggested Pressure Gauge Installations.

used on towers, pumps, and other equipment around a refinery the following remarks apply.

The 4½ or 5-inch gauge is the heaviest gauge which can be safely supported on a ¼-inch pipe connection. Use bronze tube gauges on all steam, water, and air service. Use bronze tube gauges with any other fluids if advisable from a corrosion standpoint and if fluid is non-inflammable.

Use steel tube gauges with all hydrocarbons (includes all petroleum liquids, all fuel gases and oil vapors).

A gauge range should be selected so that the normal working range is between 40 and 60 percent of the maximum range of gauge. A minimum number of ranges which will cover the needs should be selected and standardized on and carried in stock for quick installation or replacement.

The following ranges have been selected to cover our needs and these gauges are carried in warehouse stock. Every effort is made to confine our requirements to these standards. It is sometimes necessary for us to ignore the recommendation above which recommends keeping the working range between 40 and 60 percent in order to adhere to our range standards.

Bronze Tube Gauges	Steel Tube Gauges
30"— 60 psi	30"— 100 psi
0 — 30 psi	0 — 30 psi
0 — 100 psi	0 — 100 psi
0 — 200 psi	0 — 200 psi
0 — 300 psi	0 — 300 psi
0 — 600 psi	0 —1000 psi
0 —1000 psi	0 —3000 psi

Chemical Gauge (diaphragm type)

0—300 psi

There is no such thing as an all purpose gauge. After standardization, select the gauge for the particular job with care.

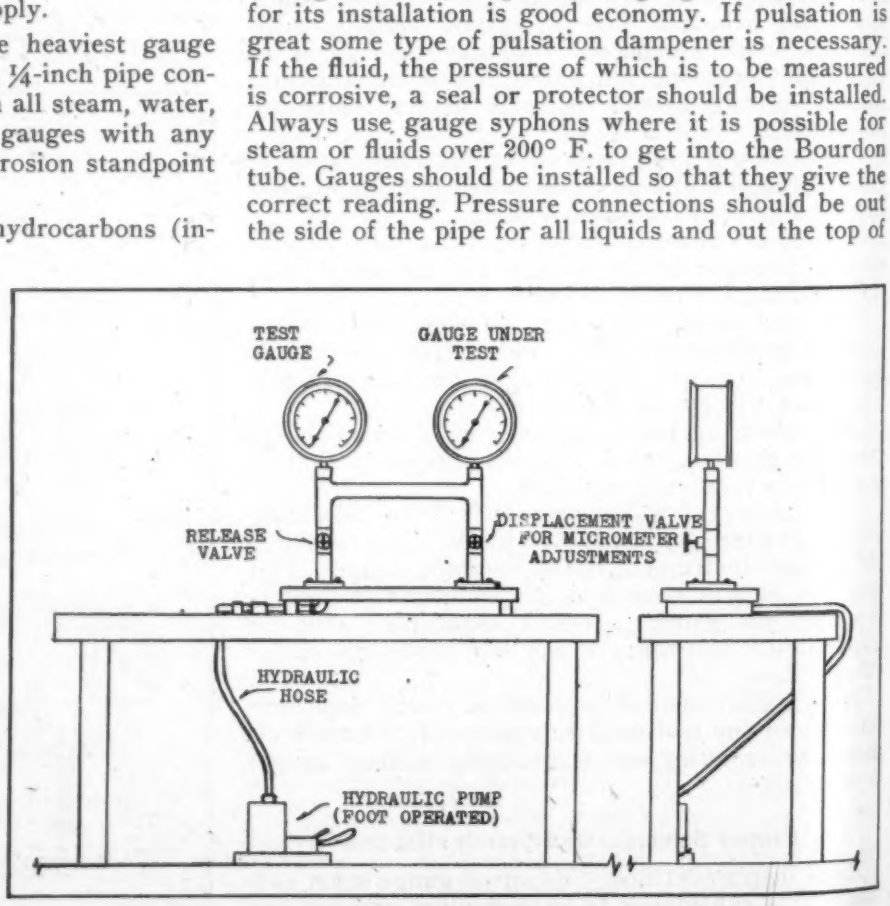
Installation

After the proper gauge is selected, the installation is very important.

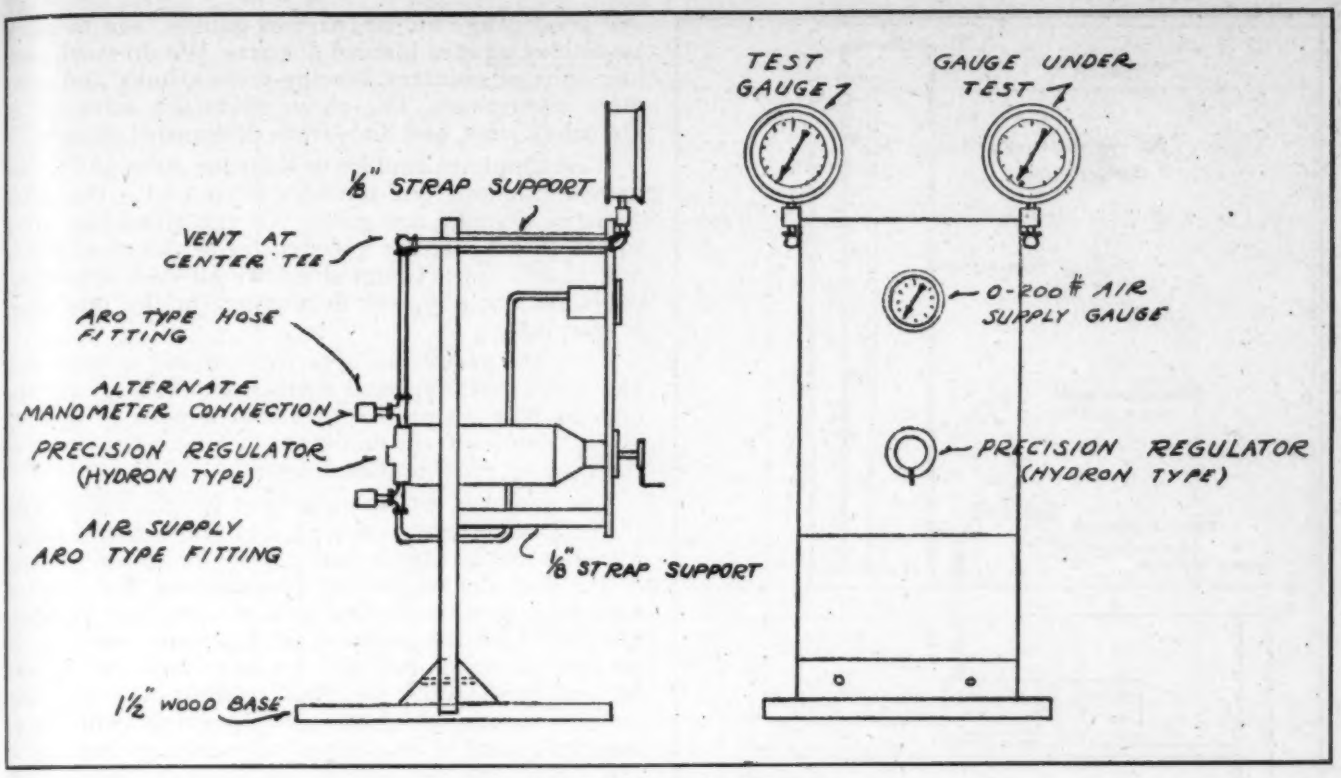
The gauge should be easy to read. Place it so that it can be read from the normal standing position. Place it so that it can be read while standing on a defined walkway or platform. If gauges are in close proximity, they should be selected so the major and minor divisions are similar and installed so that they do not invite mistakes in reading. Some gauges are divided in 5 psi minor divisions, some in 6 psi minor divisions. Two gauges like this together invites mistakes in reading.

They should be installed safely. If the vibration is great it will be necessary to brace the gauge piping. Acid or caustic gauges should be definitely marked. They should be installed with convenient and safe shut off valves so that they may be safely and readily removed for checking or replacement.

They should be installed to protect the gauge from damage. Often $10 spent for a gauge and $30 or $40 for its installation is good economy. If pulsation is great some type of pulsation dampener is necessary. If the fluid, the pressure of which is to be measured is corrosive, a seal or protector should be installed. Always use gauge syphons where it is possible for steam or fluids over 200° F. to get into the Bourdon tube. Gauges should be installed so that they give the correct reading. Pressure connections should be out the side of the pipe for all liquids and out the top of



Sketch No. 3—Hydraulic Type Comparator.



Sketch No. 4—Air-Pressure Type Comparator.

the pipe for all gases. Exception: if a gas or vapor gauge is to be sealed due to considerable condensate forming in the gauge piping, pressure connection should be on the side of the pipe, or on the horizontal.

If a liquid pressure is desired on a tower or a pipe line, it is necessary to install the gauge at this point, or at a point in the same horizontal plane, in order to get the correct pressure. If this cannot be done an error due to the difference in elevation between the pressure connection and the center of the gauge exists. Many times a pressure on the top of a tower is desired at the bottom of a tower or in a control room. The error due to the liquid head can be computed, and a correction to the gauge reading applied or the pressure gauge can be compensated for this error. This is accomplished by resetting the pointer on the gauge, to read the same as the reading of a test gauge at the pressure connection. Air transmitters should be used on pressure points of importance where large compensations would be necessary.

Pressure gauge piping should include convenient points for draining the liquid from the piping, and for installing a test gauge, and for resealing the gauge piping.

Sometimes there are installations where the gauge piping is quite long and the gauge connection is at a much higher plane than the gauge. For these installations are needed ½-inch piping and a seal pot at the pressure connection, the piping and seal pot to be filled with water, or in some cases 50 percent water and 50 percent glycerine. This liquid is pumped into the piping and up to the seal from a connection in the piping near the lower gauge. This system insures a definite hydraulic head which does not easily change and can be readily compensated for.

Checking

Before checking a pressure gauge one must decide what accuracy is needed or desired. Commercial accuracy usually means 1 percent plus or minus of total range within the middle 60 percent of the range, and plus or minus 2 percent at the lower and upper portion of the scale.

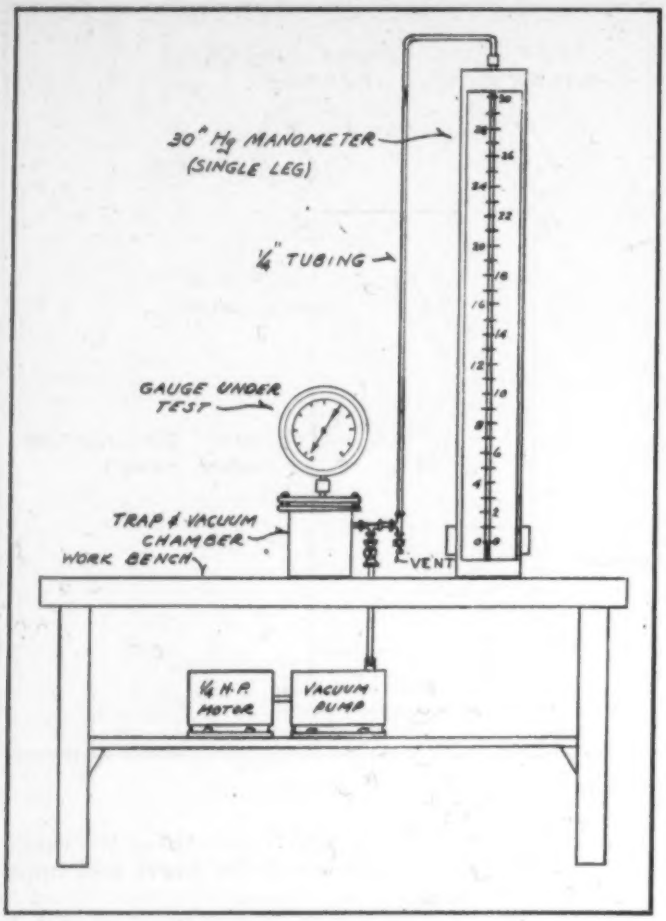
It is readily possible to calibrate most gauges to accuracies much higher than the above, and for shop testing and for all gauges used in test work or precise work we require accuracies at least 100 percent better than the above. Gauges are not always discarded if they cannot be readily calibrated to the normal accuracies required, but are often used at less important places and set correct at the normal operating pressure and are definitely marked on the face of the gauge as to the limit of accuracy. The checking of pressure gauges may be accomplished by comparison or by checking against a dead weight.

Pressure gauges are often tested in the field by comparison to a test gauge. A test gauge or master gauge is a gauge which has been carefully checked in the shop and frequently rechecked and is carefully handled and never left in use for long periods without rechecking. It may be a specially constructed gauge with many fine divisions or may be one of your best stock gauges properly marked for quick identification.

A gauge may be checked in the field by the following procedure: (1) Read the gauge to be tested; (2) remove gauge, install test gauge and again read; (3) reinstall gauge being tested and again read.

From the above observations and the action of the gauge pointer going up and down, you shoud be able to decide whether the gauge needs to be taken to the shop.

All instrument board gauges and firmly mounted gauges should be installed with test gauge connections in the rear of the board or at a convenient location. This makes possible the reading of both gauges at the same time. It is also possible to compare the gauges at several pressures, by shutting off the pressure and allowing the pressure in the two gauges to drop to some convenient readable pressure, by drain-



Sketch No. 5—Vacuum Tester

ing some of the fluid from the piping of the gauge side of shut off valve.

Gauges are tested in the shop by means of a dead weight tester or a comparator. If a gauge appears to need a complete overhaul and recalibration we send it to the dead weight tester bench. Several gauge comparators are shown on an accompanying sketch. Gauges under 100 psi are compared to a master gauge with an air pressure tester. Higher range pressure gauges are compared to a test gauge with a hydraulic pump type of tester.

Calibrations are shown on forms similar to that shown opposite in the adjoining column.

All gauges that are tested or repaired and recalibrated in our shop are painted before sending out or storing. Beside reading correctly a gauge must be easy to read, look neat and clean and inspire confidence in the person reading it.

Gauges that need a complete overhaul are dismantled and the parts cleaned, then reassembled and recalibrated on a dead weight tester. Two testers are usually needed. One with a range of weights up to 500 psi and one with a range of weights up to 5000 psi.

Repairing and Recalibrating

Practically all gauges that need repairing, need recalibration. Repairing consists mostly of replacing broken hair springs, worn gears, links, bearings, and bearing screws. It is generally our practice to salvage the parts of a gauge with a ruined Bourdon tube. It is cheaper to buy a new gauge than to have a large stock of Bourdon tubes on hand. We prefer to make one good gauge out of two bad gauges, and to stock assembled gauges instead of parts. We do stock new hair springs, pointers, bearing screws, links, and complete movements. The above parts are salvaged as are tubes, rims, and dials from dismantled gauges.

It is simple to replace a Bourdon tube and if we have one among our salvaged parts and if the other parts of a gauge are good. We cut all of our glass fronts with a circular glass cutter of the glass board and handle type. Gauge dials are cleaned, repainted, resilvered, or replaced depending on the one most economical.

After the gauge has been cleaned and reassembled and worn parts replaced with new or salvaged parts, and the hair spring has sufficient tension to take up all lost motion from minimum to maximum travel of the pointer, recalibration begins.

The gauge is set up on a dead weight tester with the dial and pointer removed, and some type of rough marking on the case indicating the mid-point reading of the dial, the 20 percent of maximum dial reading and the 80 percent of maximum dial reading. Weights are placed on the platform of the tester equal to 20 percent of maximum dial reading, and the pointer set on hand tight for this reading. By applying weights on the platform and observing readings at mid-scale, and at 80 percent of maximum reading it can readily be determined whether the mechanism must be adjusted to make the pointer move faster or slower or whether an angularity adjustment must be made.

These are the only two adjustments in the works that can be made. Angularity adjustment is made by changing the relation of the sector to the pinion gear. This is done by lengthening or shortening the connecting link or by rotating the movement. To adjust for multiplication or pointer travel, it is merely necessary to adjust the movement or sector sliding arm, to make the pointer move faster or slower.

Beginners are instructed at gauge testing on these two adjustments and on hair spring tension, and then requested to familiarize themselves with these adjust-

PRESSURE GAUGE REPORT

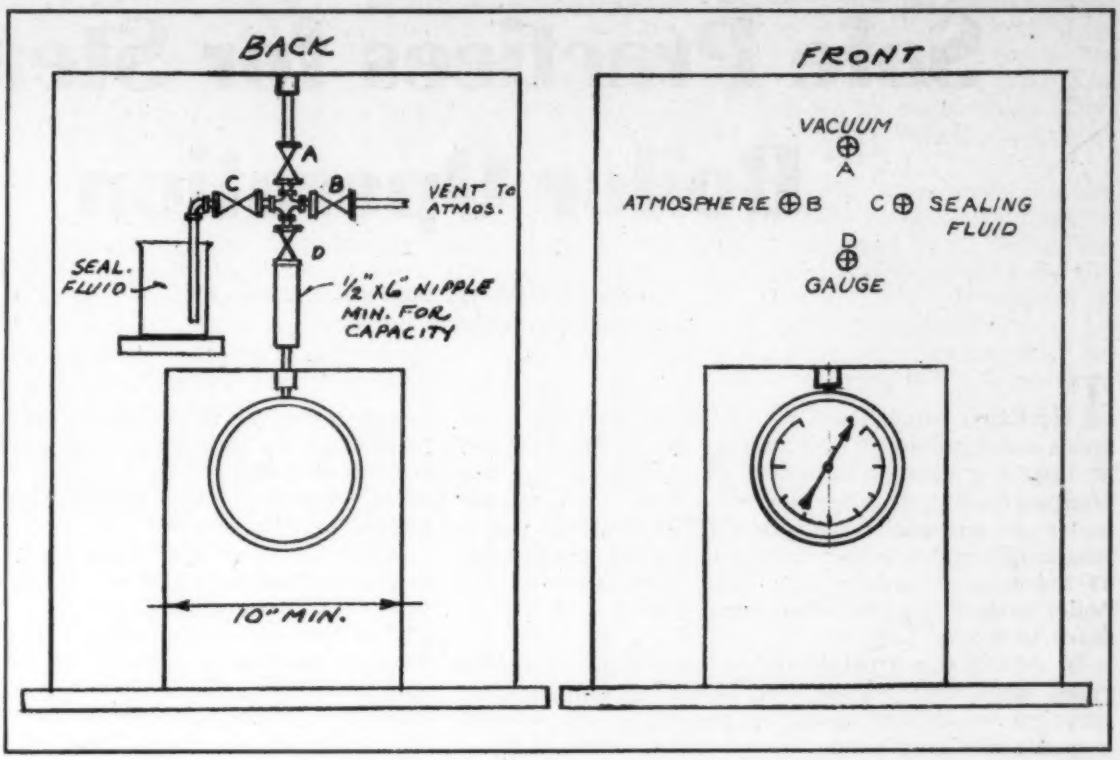
Size_____ Type_____ Make_____

Range_____ Serial No._____

OBSERVED READINGS		Corrections to be applied to gauge
Test gauge or tester	Gauge to be tested	

Date tested_____ Tester_____

Foreman_____



Sketch No. 6—Gauge Sealing Device. Directions: 1) Close B and C, open A and D. 2) Evacuate system. 3) Close A and open C. 4) Repeat steps 1 and 2. 5) After repeating three times, gauge should be sealed. Provide drip pot to catch oil and gauge opening when removing gauge. 6) Open B before removing gauge.

ments by trying many different adjustments on the same gauge and observing the results. Practice with these adjustments makes it possible to make them quickly, and without too many attempts. With these two adjustments it is possible to calibrate a gauge correctly over the entire scale.

After the gauge is adjusted to read correctly with the dial off, at three points, it should again be tested with the dial on and with the glass front on.

Tools Needed

All instrument men who are apt to be confronted with gauge jobs in the field are furnished with a gauge pointer remover or hand jack, a gauge set and a test gauge in addition to their regular kit of instrument tools.

Beside the necessary testers, test gauges and fittings to adapt all gauge connections to the testers, the following tools are desirable at the gauge bench: hand jack, hand set, four-ounce ball peen hammer, two pairs of tweezers for work with hair springs, orange sticks for cleaning bearings, pipe cleaners and brushes for cleaning, small jeweler's anvil, set of small needle files, soldering torch and electric soldering iron, jeweler's vise or small machinist's bench vise, small hand vise, set of jeweler's screw drivers, regular screw drivers and pliers, long nose pliers, a shop-made device for removing difficult rims, circular class cutter and a straight glass cutter, bottle of glass cleaner with sprayer, set of pin vises, set of pin punches, and a Yankee hand drill.

Drill press and grinder and buffer is for use by the entire instrument personnel.

Storing Gauges and Storing Parts

To test and repair gauges efficiently the mechanic should have a convenient work bench, at which he can sit on a stool with a back rest and with ample knee room. The light should be correct and tools and parts within easy reach. A bench similar to a jewelers bench with parts drawers, but on a larger scale would be desirable. Our gauge department consists of a U-shaped bench with parts drawers and cabinets below and with all of the various testers at different points on the bench ready for use after removing a canvas cover. The weights are in racks in the rear of each of the testers, at an easy arm's reach. Parts are kept in small parts drawers, each drawer being properly labeled. At one end of our gauge testing department we have a metal covered soldering bench with all the necessary accessories in drawers and cabinets below. The cleaning of dirty gauges and the painting of gauges is done outside of the regular gauge department.

Gauges carried in warehouse stock are stored on shelves in boxes. Gauges that are in rotating use in the refinery are hung on metal hooks on wall boards over the gauge bench. These gauges are arranged in rows, designating ranges, and whether steel or bronze tubes. The mechanic testing gauges can see at a glance which ranges are needed and what his stock of tested gauges consists of. Gauges to be repaired and tested are kept in cabinets below the bench in stacks of similar ranges. Every effort is made to keep the gauge bench clear of everything except the equipment mentioned and the one gauge that is being worked on.

Conclusion

Each pressure gauge installation should conform to certain standards. However, each job must be treated individually, considering safety, accuracy, ease of reading, care of gauge and economy. The accompanying sketches on suggested installations may be of helpfulness. The accompanying sketches on suggested test equipment were intended for those desiring to build their own equipment.

Give the lowly pressure gauge "a break." Select it properly, install it correctly, service it periodically, and it will give years of satisfactory service.

Safe Practices for Steam Boiler Operation

DON ATTAWAY, Safety Engineer
Arkansas Fuel Oil Company

THERE is much truth in the saying that "appearances are deceiving." The average steam plant owner or operator usually assumes, that once he has his equipment installed, the operation becomes a simple matter of automatic controls and devices that maintain ample water supply and uniform fire. So as long as there is an orderly and neat appearance to the boiler installation, he feels assured that it is a safe place to work.

In view of this attitude and in spite of the countless rules, laws, and regulations, boiler explosions continue to occur with death or serious injury to personnel and heavy property damage to owners.

The cause and correction of this condition is well known to safety authorities. It has been found to result largely from untrained and uninformed boiler firemen and engineers performing unsafe acts or creating unsafe physical and mechanical hazards.

The purpose of this article, therefore, is to detail the generally accepted safe practices that will eliminate most of the causes that so often lead to accidents. These practices are intended to supplement the laws, codes, and regulations for boilers and to apply primarily to gas-fired boilers operated in natural gasoline plants, refineries, and oil-field operations.

The most common mistake made by boiler owners and supervisors is to place this equipment under the care and attention of a man unfamiliar with the duties and responsibilities of the job. Very few companies subject boiler operators to any sort of examination or test. This conduct of operations usually results in expense or disaster. In a manner of speaking, the steam boiler is the heart of a plant operation and its failure or destruction is serious indeed.

Qualification of Operator

The first rule of safe boiler operation is to assign a trained and qualified man to this duty. He should know the theory and practice of steam generation and should be familiar with the state and federal laws as well as the requirements of the insurance company. It is highly important that he know the mechanical construction of the equipment to be able to supervise or assist in its maintenance.

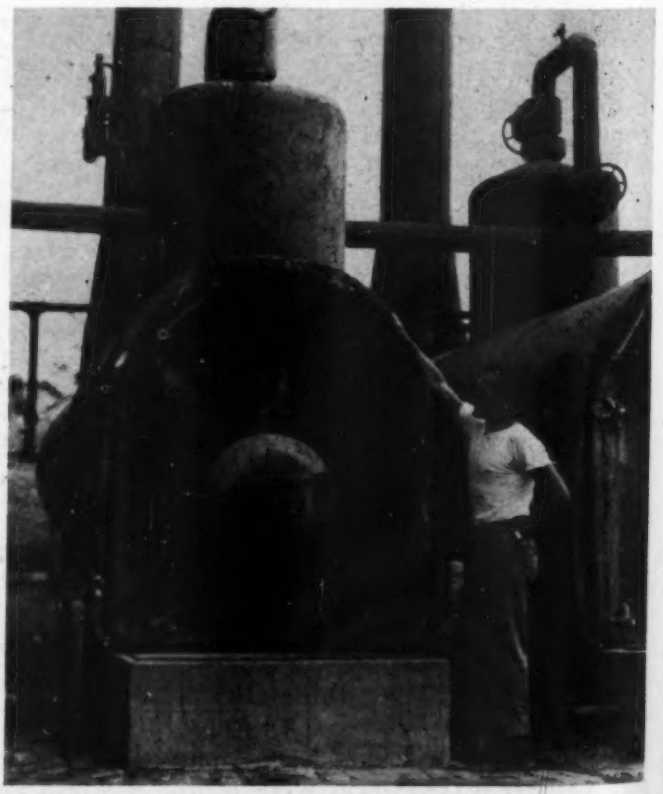
Causes of Boiler Failures

A steam boiler in its simplest form is much like the common kitchen kettle. In fact, the first steam boilers used long before the Christian era resembled a steam kettle. Thus the common boiler is a closed vessel partly filled with water which is heated by a fire. There is a steam space to hold the generated steam; heating surfaces to transmit the heat; stack to carry away the products of combustion; various piping and fittings to supply the boiler with water; relief valves to allow steam to escape when it is formed faster than it can be used; and devices for determining the amount of water in the boiler as well as the pressure of the steam. All of this makes up a simple steam plant.

Generally speaking, there are four major causes of boiler explosions when we disregard the much discussed caustic embrittlement.

The first is over pressure. There are two safety devices used to prevent this. They are the steam gauge and the relief valve. A good engineer will see that these devices are tested often and in good working order at all times. No boiler should ever be operated at a pressure greater than that permitted by law.

A second cause is low water, and there are three safety devices used for preventing this failure. Each boiler must have a water-gauge glass which indicates the level of the water in the boiler at all times. This level should be maintained half way in the glass. Three try-cocks are installed in the vicinity of the water line for checking the gauge-glass level and to serve in case the glass breaks. Water level below the gauge glass or lowest try-cock is serious. A third



The boiler fireman does not rely entirely on the water gauge glass. He checks the trycocks to be sure of his water level.

safety device is the fusible plug usually placed in boilers operating at pressures below 250 pounds and located in the crown sheet directly above the fire box. This plugs is filled with tin that melts at approximately 450° F. or when the crown sheet is dry, causing steam to escape into the fire box and extinguish the fire.

In any case where a boiler is operated with low water there is a danger and when this level is one inch or more below the glass, the fire should be immediately shut off. When steam formation has ceased, the main stop valves should be closed and the boiler allowed to cool slowly for as long as 24 hours—under no circumstances should water be fed into the boiler. Before the boiler is placed back in service, an inspector should be called to make an examination.

A third cause of explosions is deposits such as scale, oil, and dirt on the internal surfaces. When any of these accumulate on the inner surfaces of a boiler, the metal is insulated from the cooling effect of the water and becomes overheated in exactly the same way as it does when the water gets too low. Oil is the worst offender. It takes only a light coat or film to insulate the metal. The safeguard against this cause is frequent boiler cleaning and the prevention of any of these substances entering the boiler. Chemical treatment of the feed water usually corrects such causes.

The fourth cause of boiler failure is faulty or improperly made repairs. The best practice against poor and hazardous repair work is to secure approval of a boiler inspector before any repairs are undertaken. Following his approval and after completion of the repairs; the boiler should be subjected to a hydrostatic test one and one half times the maximum working pressure. A boiler is no stronger than its weakest part.

Placing Boiler in Service

Before a boiler is placed in service it should be inspected inside and out. The manholes and all other openings should be inspected and properly closed. All valves and lines should be checked with special attention given to seats, discs, and packing.

When the feed-water pump is started or the valve opened, the vents and try-cocks should be opened to permit escape of air. As soon as the water reaches the point which will be normal level when the boiler is steaming, the vents or try-cocks are closed.

The water column and blow-off valves are next checked to see that they are operative.

Starting the Fire

The furnace should be purged for at least two minutes and drafts adjusted before the fuel valve is opened. It is a good practice to locate fuel valves near the left side of the boiler. A torch on a long-wire or stick may be placed in the fire box on or near the burners. Do not stand in front of the fire box door or peep hole. Slowly open the fuel valve. Once the fire has started, it should be adjusted to a normal rate.

If the burners or fire should "snap out," the fuel must be turned off at once and the furnace purged before relighting.

Cutting the Boiler In

Bringing the boiler pressure up may require four to eight hours. It should not be done rapidly. It is a good practice to hold the pressure at 10 pounds for at least one hour. When the boiler has reached main-line pressure, the water level should be checked by try-cocks. If it is within two inches of the top of the glass, it should be blown down to normal level. The safety valve should be tested by hand chain. Discharge of relief valves should be piped to the atmosphere.

The main stop valve on the boiler must not be opened until the drain has been closed. Opening the main gate must be done slowly and never before the boiler and main line pressure are approximately the same. If lines are cold, all drains must be opened to remove water, and steam admitted slowly.

Once the boiler has been cut in, attention must be given to firing and feed-water rate and adjustments made for normal operation.

Operating the Boiler

One of the most important rules of boiler operation is proper and uniform water level. The water column and gauge cocks should be blown several times during each tour. All gauge glasses should be visible and guarded with screen mesh wire. Dirty or cracked glasses should be replaced immediately.

Foaming. and priming are two conditions that should be immediately reported to the supervisor. Foaming usually means that impurities such as oil, scale, or high concentrations of chemical solids are in the water.

Priming usually means that the water level is carried too high or that the boiler design is such that the steam area is too small, however, the general cause of priming is excessive rates of steaming in well-designed boilers.

High feed-water pressures sometimes mean that the piping has become choked with scale or sediment. In such cases, lines should be promptly inspected and repaired.

Equally important as water level is maintaining a uniform fire to avoid incomplete combustion and possible gas explosion. Proper air adjustment must be had at all times. Automatic fuel regulators are very dependable but even these sometimes fail.

Blowing Down

It is a safe practice to blow each boiler down with a full opening of the valve at least once each eight-hour shift. When water is bad, the operation must be repeated at shorter intervals.

Mud and sludge will settle to the bottom water spaces when a boiler has been shut down and once

Normal operations call for a boiler blowdown at least once each tour.

steam generation has stopped; opening the blow-off usually will draw off considerable amounts of mud.

The blow-off should be opened and closed slowly. Sudden operation of the valve throws a considerable strain on the throat sheet. It is a good practice to blow down about three inches of water in the gauge glass if the level is normal, or more if it is high. Do not blow down a boiler until the water is below the bottom gauge cock.

Each boiler should have a quick-opening and a stop valve on the blow-off line. The quick opening valve is first opened, and then the stop cock slowly opened. In closing, the stop cock is first slowly closed and then the quick opening valve. Both valves should be checked for a tight shut off.

Only one boiler at a time should be blown down. In case any boiler on the line is shut down for any reason, it must be checked first to be sure that no valves are open whereby steam could enter it. Boilers with blow-off lines entering a common header are dangerous unless precautions are taken to be sure that no person is in a position to be struck by steam and water. This means that all persons in a boiler house must know when boilers are about to be blown down.

Steam boilers should never be left unattended longer than 20 minutes, even in emergencies.

Taking the Boiler Out of Service

One of the most common abuses of safety is taking a boiler out of service too rapidly. The first step is to shut off its fuel. Time must then be allowed for steam generation to cease, before the main stop valve on the boiler is closed. In case of two valves, both are closed and the drain opened. The boiler should be allowed to cool slowly. Sometimes this takes as long as eight hours. The boiler may be emptied before it is cold as this will prevent the setting of scale on tubes and heating surfaces, but boilers must not be blown dry while they are hot. When pressure is off the boiler, a vent should be opened so that a vacuum will not be created as the water is discharged.

As soon as the boiler is empty, the blow-off valve should be closed and all vents, man hole, and other plates removed.

Cleaning

Before allowing any man to enter a boiler, a careful check should be made to be sure that all gates, valves, and lines are blocked, closed, or disconnected so that no steam, water, or gas may enter the boiler. These should be tagged with "do not open" signs or "man in boiler" tags.

The boiler should be well ventilated and cool before entering. Tools should be inspected for good working conditions. Extension cords must be examined for defects. A faulty electric light in a wet boiler is capable of electrocuting a man.

In washing out with a pressure hose or removing scale with tools, the workmen should wear goggles.

Repairing

Repairs must never be made on a boiler, steam line, or any fitting under pressure. Never attempt to tighten flange bolts, stay bolts, leaky packing glands, or unions even on small lines under pressure. This has caused numerous serious accidents.

In case a tube ruptures, the repair should be made as soon as possible. The boiler is taken out of service in the normal manner and the feed water left unreduced unless the damaged boiler is drawing too heavily on the supply.

When a leak is discovered near a seam or flange, the boiler must be taken out of service and the pressure reduced slowly to prevent stress and strain on the damaged part.

Housekeeping

Boiler rooms and floors should be kept orderly and clean. Loose tools, uncoiled hose or extension cords left carelessly on floors and in corners lead to serious accidents. Wet floors are a very bad slipping hazard.

All windows should be kept clean so that ample natural light is available. Where electric lights are used, they should be kept in good repair with extra bulbs and reflectors on hand. Special care should be given to lighting gauges, water columns, stairs, steps, and passage ways.

Each boiler house requires two or more exits. These should be alternated so that there is a door at the back of the boiler for each door at the front or side. A good practice is to install one door for each two boiler settings. Doors should open outward and these passages must be kept clear and unblocked.

It is a good safety rule to prohibit visitors and other persons from loitering in the boiler house where the curious turning of a valve or other control may cause an accident or damage to the equipment.

Ample cool drinking water should be available for boiler attendants. Extremely cold ice water is not recommended. The boiler house should have ample ventilation so that all gases and fumes will be vented. A supply of salt tablets should be provided for the workers during hot weather.

Clear lens goggles and respirators should be available at the boiler house for the use of workers engaged in repairing or cleaning boilers—boiler scale and dust is very injurious to the eyes and lungs.

General

During the past war years maintenance of boilers has been somewhat curtailed and a great deal of boiler equipment today does not meet all code requirements. The sudden demand for activity caught this equipment unprepared for full and steady use but in the emergency it was placed in service and it has been difficult to spare it long enough for overhaul or proper repair. Therefore, it is highly important that these boilers be operated in the safest possible manner until the deferred repairs can be made.

At the same time the operators, engineers, and firemen should be alert for conditions exposing life, limb, and property to the hazard of accidents resulting from unsafe operation.

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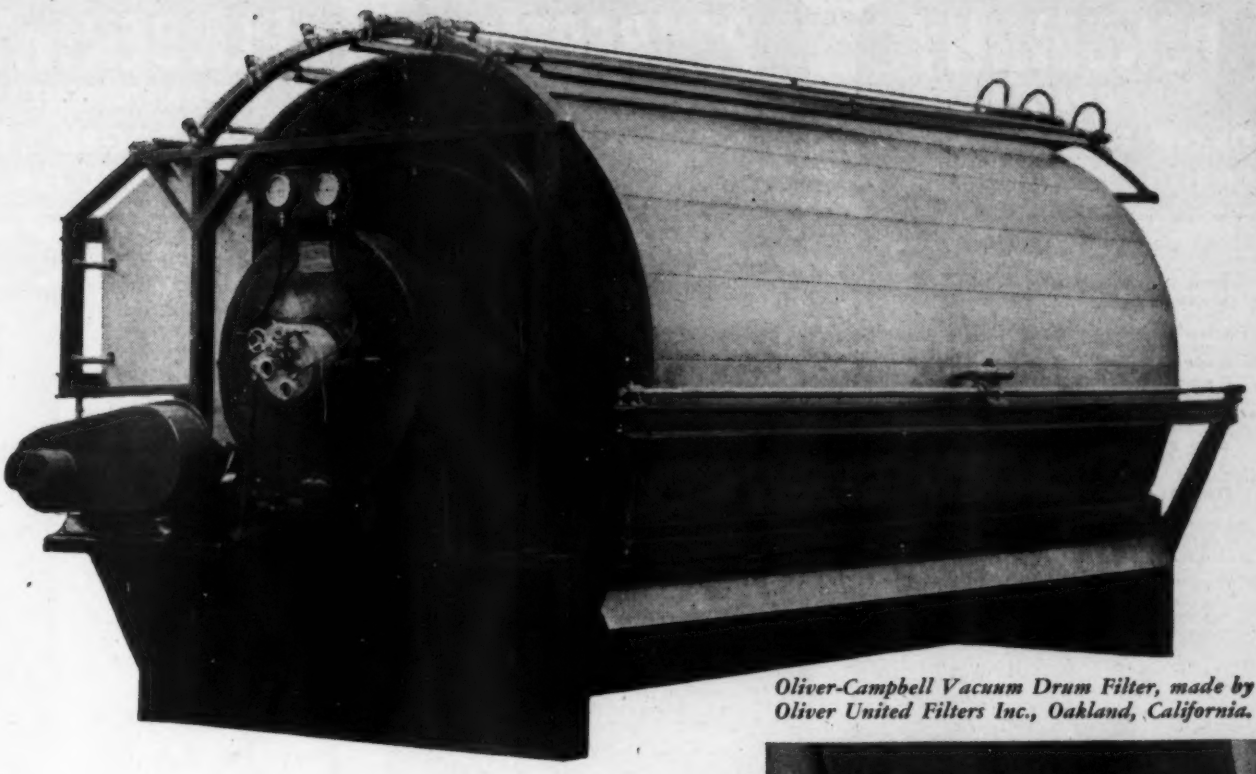
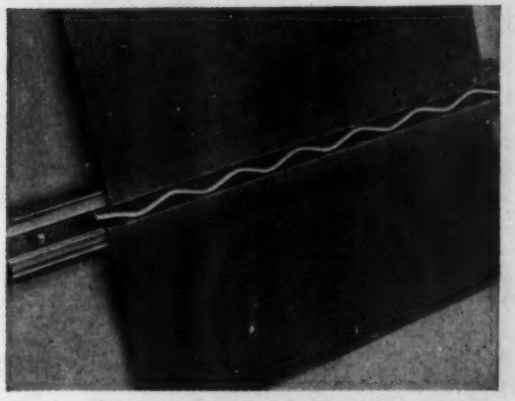


Oliver-Campbell Vacuum Drum Filter, made by Oliver United Filters Inc., Oakland, California.

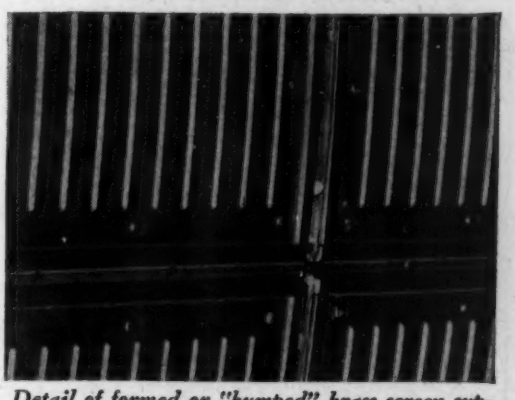
6 types of REVERE METALS in this vacuum drum filter

In the manufacture of this Oliver-Campbell Sugar Cane Mud Filter the following Revere Metals are used: Copper sheet, copper tube, brass sheet, brass discs, brass pipe, and brass extruded shapes. These metals are chosen for three chief reasons: they resist the corrosive action of the filtrate and cake, their mechanical strength is such as to assure durability, and they are quickly and economically fabricated. Use of extruded shapes is particularly interesting from a fabrication standpoint, the rather complicated forms required for the division strip being supplied by Revere in straight lengths that require only cutting and drilling before installation. Similarly, the zig-zag caulking strip that holds the screens is a Revere rectangular extrusion that needs only cutting plus formation of the zigs and zags. The screens, incidentally, are copper sheet, perforated 625 holes to the square inch.

Filtration is an important process, not only in sugar mills, but in a great many industries, such as chemicals, petroleum, coal, paper, cement, mining and refining, breweries, sewage disposal. Often both filtrates and sludges are corrosive, and thus it is that Revere Copper and copper alloys find many important applications. These metals are available in many different alloys and forms, resistant to a wide range of corrosive media. The Revere Technical Advisory Service will gladly collaborate with you in studying the problem of corrosion in your plant equipment or product.



Section showing method of locking copper screen into the extruded division strip by means of a zig-zag brass caulking strip.



Detail of formed or "bumped" brass screen support. The division strips are extruded brass sections.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.

Sales Offices in Principal Cities, Distributors Everywhere

PENBERTHY

"REFLEX"

DROP FORGED STEEL LIQUID LEVEL GAGES

Liquid always shows black—empty space shows white. Preferred where the liquid level must be easily and positively visible, and when liquids are under high pressure or at high temperature. Made of alloy temperature resisting steel and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Reflex" is one of the complete line of Penberthy Gages that meet every liquid level gage requirement.

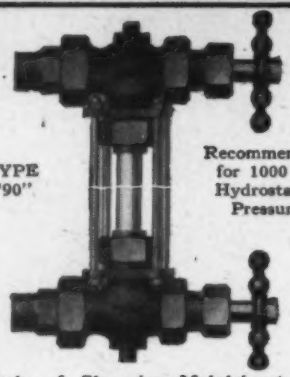
PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY

DROP FORGED STEEL

LIQUID LEVEL GAGES



TYPE "90"

Recommended for 1000 lb Hydrostatic Pressure

Made of Chromium-Molybdenuin alloy temperature resisting steel, extra heavy throughout and stainless steel trimmed. Positive automatic shut-off; stainless steel balls shut off the flow of liquid if glass breaks. Regrinding removable seats, heavy duty stuffing boxes, union connections. Conform with A.P.I.—A.S.M.E. requirements.

This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

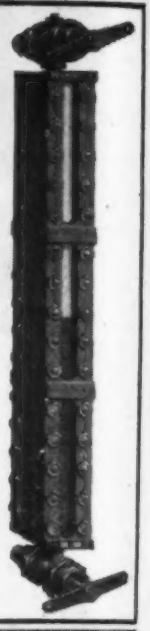
PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY

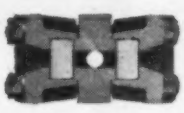
"TRANSPARENT"

DROP FORGED STEEL LIQUID LEVEL GAGES



Used to observe color and density of liquids under high pressures and/or temperatures. Construction exceptionally sturdy. Made of alloy temperature resisting steel, and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Transparent" is one of the complete line of Penberthy gages that meet every liquid level gage requirement.



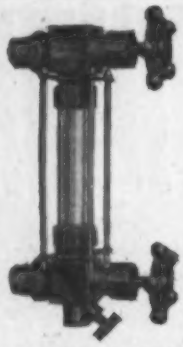
PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY

"ALL IRON"

LIQUID LEVEL GAGES



Body made from a special high strength alloy iron, shanks alloy steel and trim stainless steel. Extra heavy construction throughout, automatic and positive shut-off if glass breaks, heavy duty stuffing boxes. Conform with A.P.I.—A.S.M.E. requirements.

The "All Iron" is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY

QUALITY PRODUCTS

Penberthy injectors—ejectors—automatic electric and water (or steam) operated sump pumps are all widely used throughout the oil industry because they have always been dependable under the most severe service conditions.

All are of rugged construction and made by an organization with 59 years experience in the manufacture of highest quality products.

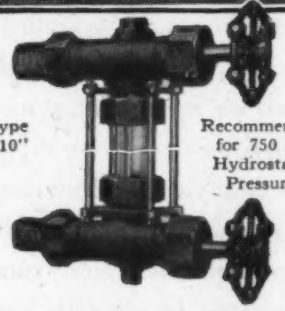
PENBERTHY INJECTOR CO.

DETROIT 2, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY

DROP FORGED STEEL

LIQUID LEVEL GAGES



Type "10"

Recommended for 750 lb. Hydrostatic Pressure

Steel construction throughout with stainless steel interior trim. Automatic shut-off is positive and instantaneous; stainless steel balls shut off the flow of liquid when glass breaks. Heavy duty stuffing boxes, union connections, offset construction facilitate cleaning and simplify glass replacement. Conform with A.P.I.—A.S.M.E. requirements.

This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

REFINER AUTHORS . . . . . and OTHER PERSONALITIES

Fowle and Bent Sour Crude Authors

THE co-authors of "Where Does the Sulfur Go?" (an API paper which starts on page 87 of this issue) are both with The Atlantic Refining Company, Philadelphia, and reading their article will convince you they have done a good job summarizing product quality by different methods of processing sour crudes.

M. J. Fowle is a 1929 graduate of the University of Wisconsin, B.S. in chemical engineering. He was with Socony-Vacuum and then with du Pont before joining Atlantic in 1934. His present post is division director of research and development work on motor fuels and related products.

R. D. Bent took his B.S. in chemical engineering at the University of Pennsylvania in 1935 and has been employed by Atlantic since his graduation. He is now assistant in charge of development work on motor fuels and applied products.

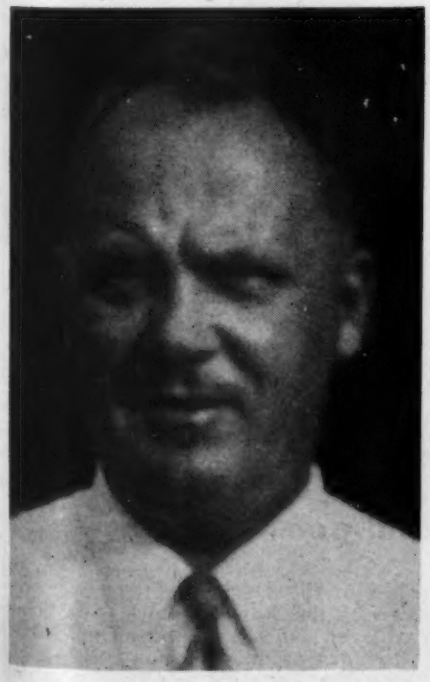
M. J. FOWLE

R. D. BENT

Finn Devotes Time To Flange Formulas

HERE'S a Finnish fellow who decided that there is a definite need for simple methods of calculating flanges and dished cover plates—and is doing something about it.

Harald E. Lonngren, author of "Flange Design Construction," page 130, was born in Finland, attended the "Tekniska Hogskolan" in Helsingfors and was graduated as "diplom ingenieur" in 1925. He was employed in Finland as mechanical engineer in charge of steam boiler and pressure vessel design and fabrication before coming to the United States where for 11 years he devoted himself to steam boiler work, this with such well known firms as Erie City Iron Works, Riley Stoker Corporation and Combustion Engineering Company. In 1940 he entered the oil business, joining Standard Oil Development Company where his present duties involve checking of pressure vessel and heat exchanger drawings.



HARALD E. LONNGREN

Here's where he found the need for simple calculating methods; so he has devoted much of his own time to develop new formulas. These, he felt, would be of great help to designers of pressure vessels; so consequently he put them in shape for publication in THE REFINER. Curently Lonngren is engaged in working out a simple chart by means of which a flange designer can determine the all-important value of g_1 (thickness of the hub at the back of the flange.) His charts will be published shortly in these pages.

For relaxation—since extra avoirdupois divorced him from javelin throwing and diving—Lonngren takes weekend motor trips out of New York, only bad weather stopping this routine. He and his wife enjoy regular games of chess and on occasions he resorts to the old Yankee standby, the cross-word puzzle, to get his mind off his work.

Medal to Pennington

Dr. W. A. Pennington, chief chemist and metallurgist of the Carrier Corporation, Syracuse, N. Y., has been awarded the 1947 Henry Marion Howe Medal, an award made annually by the American Society for Metals to the author of the technical paper of highest merit published in the annual Transactions of the Society.

C. R. OLSEN

Pacific Area Vet Co-Author of Paper

C. R. OLSEN, chemical engineer with Universal Oil Products Company, Chicago, is co-author of "Plant Evaluation of Fluid Cracking Catalysts," (see page 104) which was delivered early this month at an API Division of Refining symposium on cracking catalysts. H. W. Grote of the same company is the other author.

Olsen was graduated by the Univer-

sity of Minnesota with a B.S. in chemical engineering. He joined Universal immediately thereafter, and worked in the pilot-plant division until 1941. He then entered the army, serving in the coast artillery for 4½ years and seeing service in the Solomons and later in the Philippines. In November, 1945, he returned to the UOP pilot-plant division, and joined the engineering research and development department in February, 1947. In that group, he is now working on catalytic cracking.

Pink Grapefruit And Woodworking

"INVESTIGATION of a Girbotol Unit," starting on page 107, is co-authored by Frank R. Clegg and W. E. Norris, both connected with The Pure Oil Company's Smiths Bluff refinery staff.

Clegg (B.S. Ch.E., Arkansas, 1933) joined the laboratory staff of Pure's Muskogee, Okla., refinery in October, 1933. In 1937 he was transferred to Pure's Cabin Creek, W. Va., refinery and in 1938 entered the research and development laboratories at Northfield, Ill. He has been at Smiths Bluff, Texas, since 1940 and is currently assistant resident chemist. His chief interests are amateur radio and electronics, followed by bowling, fishing and, to some extent, raising avocados and pink grapefruit. "In a small way," is his comment re the two last-mentioned pursuits, this perhaps so his friends won't expect shipments by the crate this fall.

Norris (B.S. Ch.E., 1941, Alabama) went to work for International Paper Company, Panama City, Fla., right after his graduation. In 1942 he moved to Beaumont, Texas, and joined the laboratory staff of Pure at Smiths Bluff. Here he has worked since. His main hobby is woodworking and, this avocation must be coming in handy, because right now he is fixing up a new home.

W. E. NORRIS

WILLIAM F. LOWE

He Learned About Oil The Hard Way

WILLIAM F. LOWE of Tulsa has been secretary-treasurer of the Natural Gasoline Association of America for the past 13 years and is considered not only a top flight organization man but an expert engineer in the natural gas field.

He was born at Benton Harbor, Mich., and obtained his A.B. degree in geology from the University of Michigan in 1924. He entered the oil industry the hard way, gaining practical field experience as roughneck and tool dresser in the Salt Creek pool, Wyoming, with the Midwest Refining Company. In 1926 he became geologic scout for Midwest Exploration Company with headquarters at Amarillo, Texas, remaining in that position until 1934 when he moved to Tulsa as a feature writer for *National Petroleum News* and then to Cleveland, Ohio, as Technical Editor for *International Petroleum Technology*.

He was named secretary-treasurer of the Natural Gasoline Association of America in 1934. He is a veteran of World War I, having served in the Navy as chief gunner's mate.

Lowe's article starts on page 125.

FRANK R. CLEGG

Pompeo Grew Up With Shell's Laboratories

D. J. POMPEO, author of "Application of Viscosity Measurement in Refining Operations" (page 101), was born on April 26, 1901, in Jersey City, N. J. After receiving his elementary and intermediate education in that city, he attended the California Institute of Technology, Pasadena, where he received the B.S. degree in Physics and Engineering in 1926. During the next two years he gained technical experience at the Mount Wilson Observatory, Pasadena, and at the California Institute of Technology.

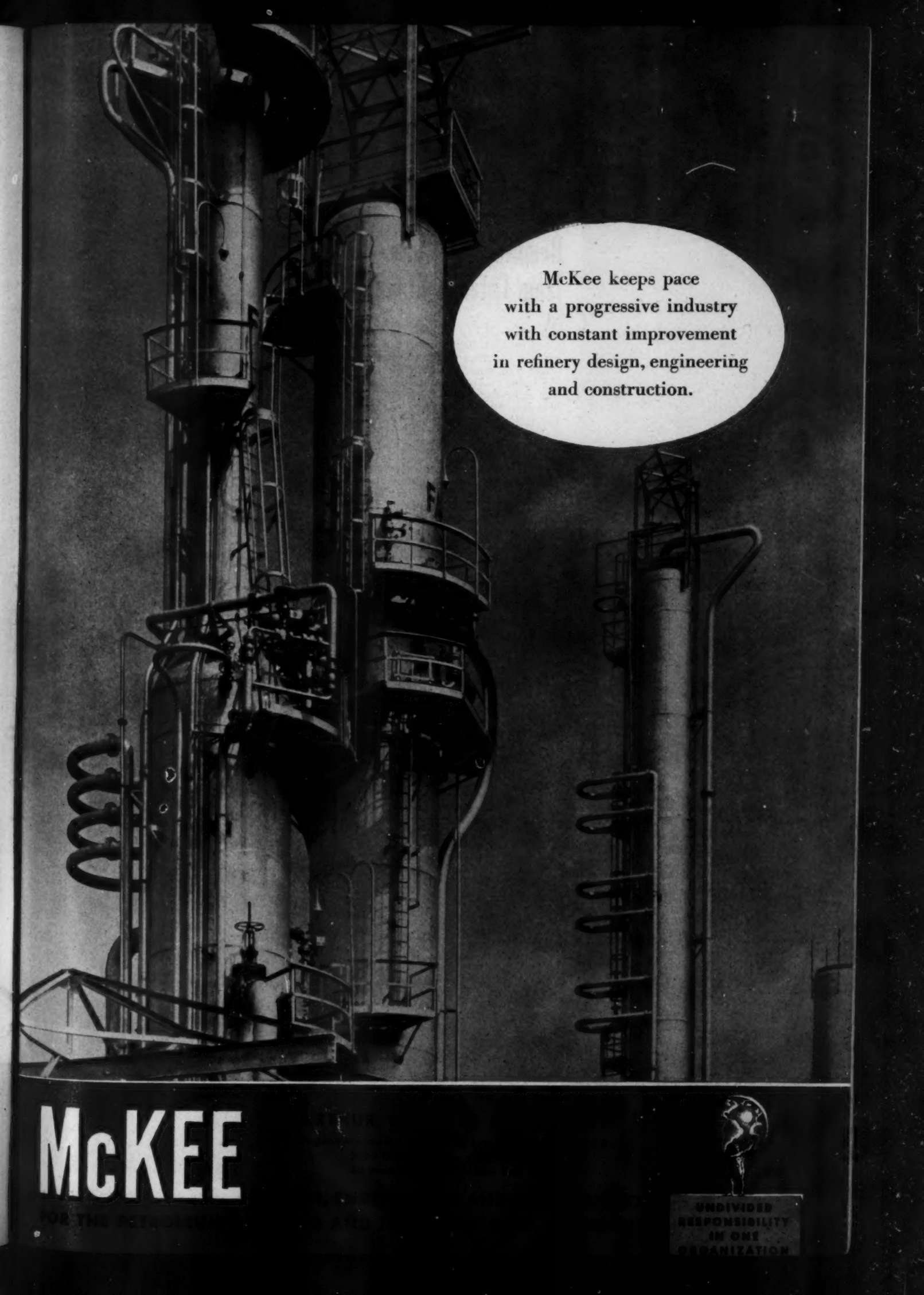
Pompeo joined the staff of Shell Development Company at the time of founding of the Emeryville laboratories in 1928, and organized their instrument development and glass blowing activities. He is now head of the instrument and glass blowing department there.

D. J. POMPEO

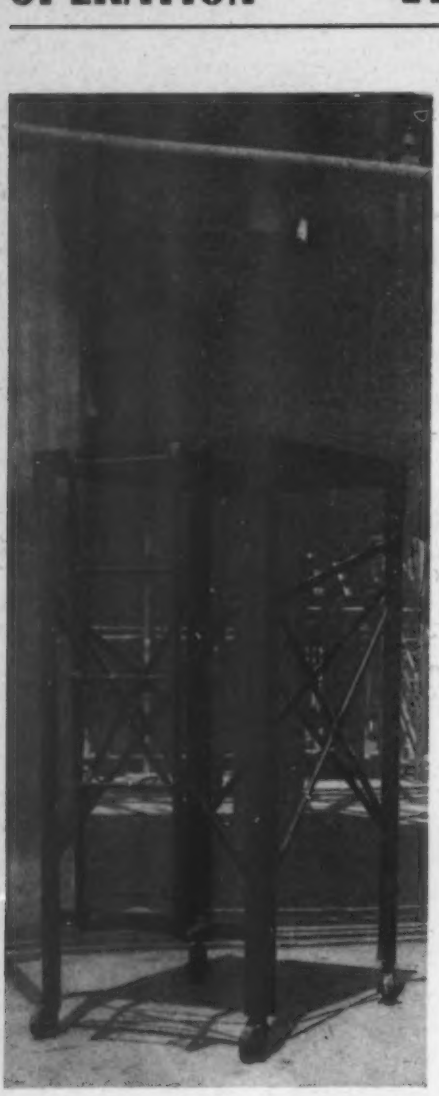
For years Pompeo has been active in developing equipment for laboratory research and plant measurement and control in petroleum and chemistry.

Corrosion Chief

Irving A. Denison has been appointed chief of the underground corrosion section of the National Bureau of Standards and will direct fundamental studies of underground corrosion utilizing the data from extended field tests. This program began in 1922.


McKee keeps pace
with a progressive industry
with constant improvement
in refinery design, engineering
and construction.
McKEE
UNDIVIDED
RESPONSIBILITY
IN ONE
ORGANIZATION

OPERATION HOW TO DO IT MAINTENANCE



Photo, above, shows portable platform which has been found to be a handy piece of equipment in The Pure Oil Company's Smiths Bluff refinery, Nederland, Texas.

HOW TO—

Facilitate Work With Portable Platform

A PORTABLE elevated work platform which provides ample work space and safety for the worker is used at the Smiths Bluff refinery of The Pure Oil Company. The platform is a table affair with elongated legs, mounted on casters, and is easily moved from one place to another. A steel ladder welded to one side provides access to the work platform. Such a piece of equipment is ideal for scraping and painting of lines, greasing and maintenance of overhead valves, and work on elevated installations in general.

HOW TO—

Remove Slide Valve From Catalyst Standpipe

A SPECIAL trolley and cradle devised by Gulf Oil Corporation engineers, greatly shortens the time required to remove the giant, 34-inch slide valve on the spent catalyst standpipe. The method not only decreases the time factor but also the number of men required to do the job and makes for greater safety.

Trolley beams were installed as soon as the oil was out of the unit. After removal of the flange bolts, a special cradle which had been fabricated before the unit went down, was bolted to the valve bonnet and attached to the trolly via a chain pulley. All that was necessary then was to push the valve out of the standpipe, roll it along the beams, and lower it to the floor. Trolley beams were left in as a permanent installation.

Slide valve removal arangement.

This arrangement shortened the down time during the turnaround and prevented the occurrence of any lost time accidents on this Kellogg-designed unit.

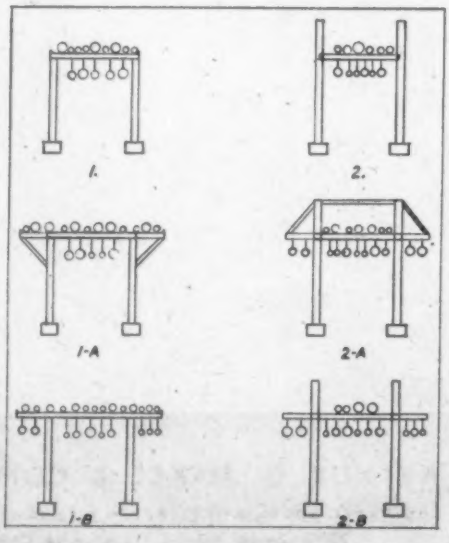
HOW TO—

Enlarge Pipe Supports In Gasoline Plant

THE addition of new columns or units to gasoline and cycling plants for production of more products presents the matter of pipe supports for the piping involved. Several methods of solving the problem have been used in various plants besides adding new supports.

In plants where the support of Figure 1 was in use, side extensions and braces were used to increase the capacity of the support, Figure 1-A, or the cross-member of the support was replaced, as shown in Figure 2-A. The method of Figure 1-A permitted additional lines to be laid only on top of the extensions because of the bracing that was needed. By replacing the cross-member with a longer beam, pipes could be suspended below the extension. In both cases, the foundations and vertical supports of the cross-members were strong enough for the added load.

The supporting area of Figure 2 was increased in Figure 2-A similarly to that of Figure 1-A, except the extension braces are above the cross-member and the additional pipes must be suspended. In Figure 2-B, replacing the cross-member with a longer beam further increases the supporting area by the area on top of the extensions.



Pipe support suggestions.

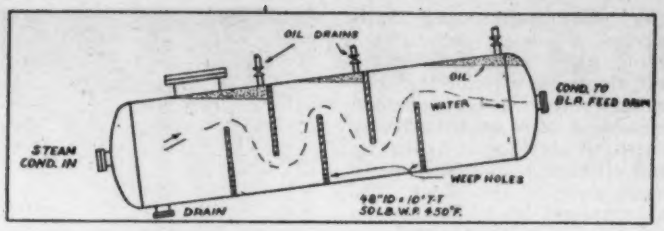
HOW TO—

Separate Steam Condensate From Oil

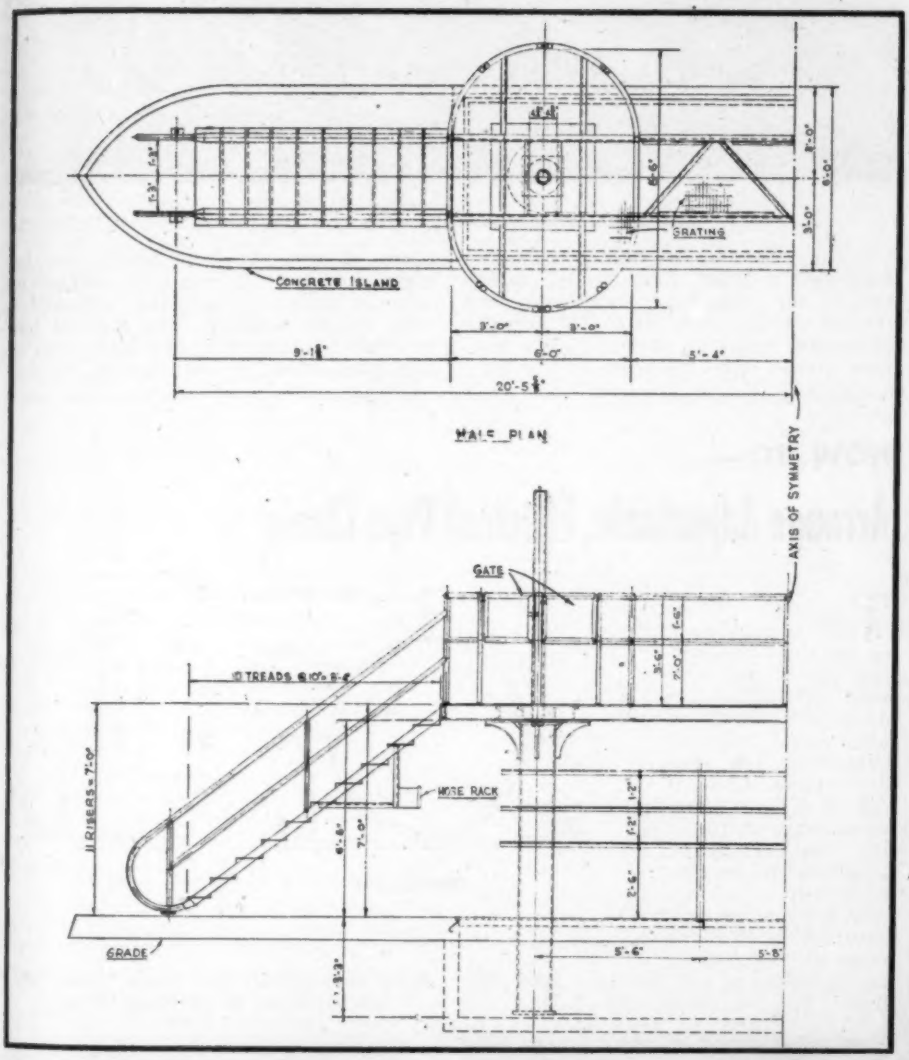
STEAM condensate recovery in West Texas gasoline plants is an extremely important item in operating economy, due to the lack of water for boiler feed that does not require extensive treating before use.

The drum shown in the sketch has been used satisfactorily in several West Texas plants to separate contaminating oils from the 5-pound exhaust steam in the condensate recovery system. Five baffle plates, arranged as shown in the

accompanying drawing of the drum, direct the flow of condensate from the inlet to the outlet and serve to trap the oil. Connections in the top of the drum permit the oil to be drained off the condensate. The drum is 48 inches in diameter and 10 feet in length, which permits handling of large volume of condensate at a low velocity for separation. Weep holes in the three lower baffles, and the slight angle of the drum facilitates draining sediment accumulation.



Separation of steam condensate and oil.



HALF PLAN

HALF ELEVATION

HOW TO—

Design a Truck Loading Rack

IN MANY of the older gasoline and cycling plants, the loading racks for tank trucks and railway tank cars were regarded simply as points where the products of the plant were loaded for transportation to various markets. Such methods were in keeping with the general attitude toward the appearance of the plant.

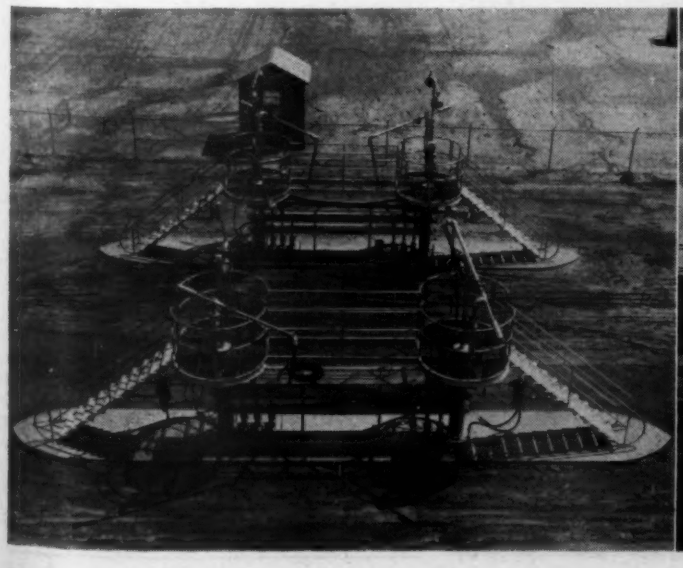
In recent years, however, the attention given the over-all appearance and attractiveness of plants has shown a marked upswing—providing better working conditions for employes, a reduction of maintenance required by weather conditions—all indicating high general efficiency to an observant public.

Typical of many improvements developed in the natural gas-gasoline industry is the loading rack shown in the

At left—Half plan construction drawing of the loading racks. Lower half shows elevation.

Photo at right bottom of page—The space beneath the racks is utilized to provide storage for loading hose. Products are piped to the loading racks from the storage tanks shown in the background.

Lower left photo is view of the loading racks from one of the floodlight towers, which shows their stream-lined construction of welded tubular material on the concrete "island" foundations.



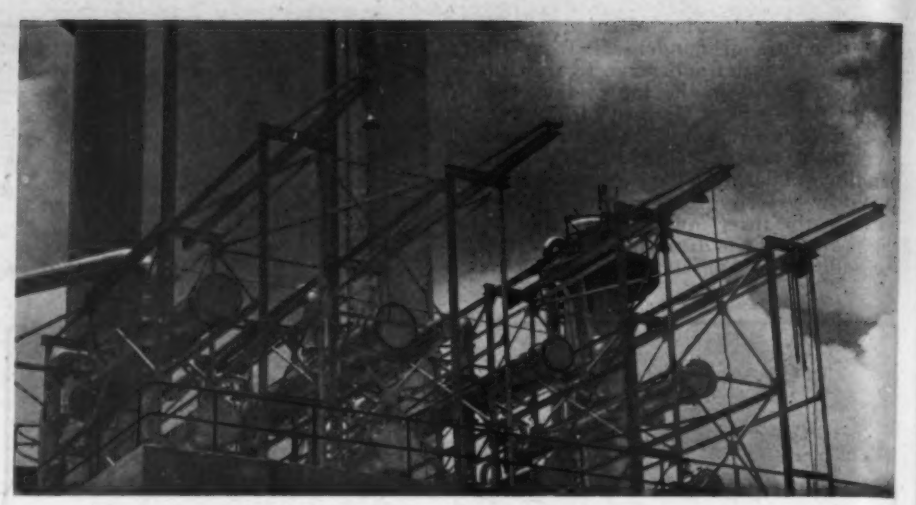
accompanying photographs and half-plan drawing.

The gasoline plant and the loading rack are built alongside a main highway providing accessibility. It was decided to build the loading rack as attractively as possible without sacrifice of operating flexibility and efficiency, and in keeping with the appearance of the plant. The stream-lined structures built have proven satisfactory from every standpoint.

As will be noted from the half plan drawing, the structure is seven feet above the concrete island foundation, which is high enough to provide the loading operator with easy accessibility to the top of the tank truck, through gates on either side of the product line riser, for connecting loading lines. The loading lines are connected to the product line risers by swivel joints and are counter-balanced for ease in handling.

Product lines from storage tanks to the loading racks are underground and are connected to the risers from concrete-lined pits beneath the racks. The lines are manifolded and equipped with valves shown below the racks for various products. A valve at the top of the riser just below the swivel joint is used by the loading operator in filling the tank trucks.

Other details of the rack are shown on the half-plan and accompanying photographs.



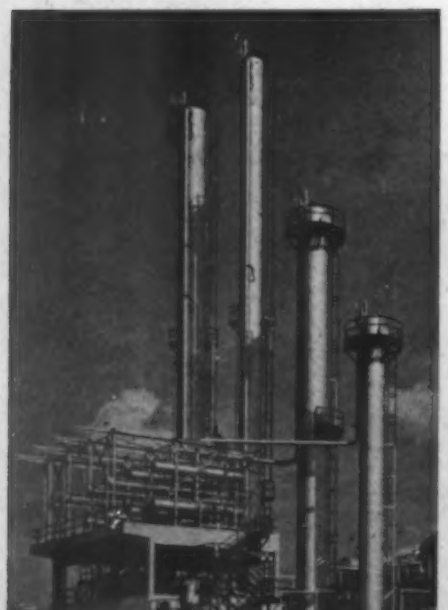
Closeup of platform showing trolley rails and hoists.

Company, Inc., by installation of trolley rails and a hoist. Each trolley serves two of the eight heat exchangers, and the hoist is moved to the trolley over the exchanger requiring servicing. The trolleys extend over the edge of the platform, so that the tube bundle can be cleaned in place, or removed, lowered to a truck hauled to the plant shop, and a new bundle installed. The method has simplified exchanger overhaul with a resulting saving in man-hours.

HOW TO—

Facilitate Tube Bundle Removal From Exchangers

THE PRACTICE of using elevated platforms for tower heat exchangers and condensers to provide adequate pump suction heads, and conserve plant space, oftentimes causes difficulties in removing the tube bundles for repairs and replacement. This difficulty was eliminated in the photograph shown of the Sheridan cycling plant of Shell Oil

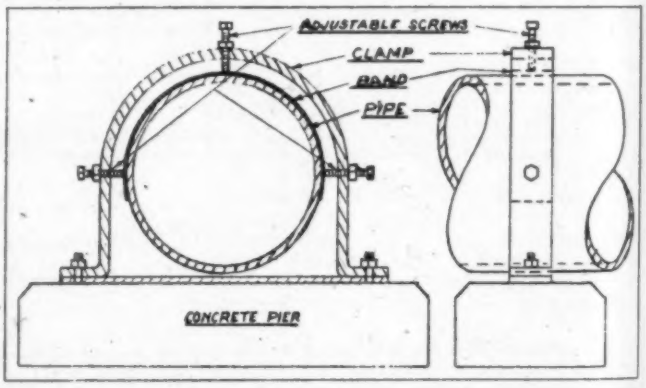


Device which facilitates removal of tube bundles from tower heat exchanger.

HOW TO—

Arrange Adjustable, Efficient Pipe Clamp

THE pipe clamp in the accompanying sketch has been used throughout a gasoline plant on pipe lines that are supported on concrete piers. Consisting of a heavy steel strap shaped to fit the pipe, the clamp has three set screws, each with a locknut, which may be adjusted to center the pipe in the clamp, and is bolted to the pier on a steel strip base.



Detail of adjustable pipe clamp (above) and, at left, photo of the clamp in use.

The construction of the clamp permits longitudinal movement of the pipe due to temperature expansion and construction. A band covers the pipe to prevent the points of the adjustable screws from cutting the protective coatings on the pipe.

PETROLEUM REFINER

welcomes items (with photos or sketches) for the "How To Do It" Section.

Exchange your idea for a check!

Cycling and Other Natural Gas Problems Discussed at CNGA Annual Meeting

By C. CLYDE PRYOR, Associate Editor

Papers on five controversial subjects of great interest to the natural gas-gasoline industry drew approximately 300 members and visitors to the 22nd Annual Convention of the California Natural Gasoline Association in Los Angeles, California, October 10. More than 800 attended the evening banquet and show at the Ambassador Hotel. Motor fuel sensitivity, centrifugal compressors, cycling, natural gas for California, and the fuel and energy outlook for the West were the topics presented by outstanding authorities in their fields.

Marion E. Dice, manager of the economics department, General Petroleum Corporation, in discussing, "The Fuel and Energy Outlook for the West," pointed out that petroleum shortages since the war have not existed due to lack of production or stocks on hand, but are due to transportation facilties and demands of government agencies for petroleum products when their appropriations have been granted. Substantiating figures were quoted.

Dice attacked the current idea of conservation for future generations and told the gathering that conservation should mean economic utilization and that the present generation should realize the benefits of natural gas and petroleum. New sources of energy will be found for the use of future generations, he said, and suggested that atomic energy" may be just around the corner."

Centrifugal Compressor Selection

"Centrifugal Compresor Installation at Seeligson Project," by Dan McDonald, chief process engineer, natural gas department, Magnolia Petroleum Company, was a presentation of the considerations involved in selecting centrifugal compressors—considered a revolutionary development in gasoline plant practice. McDonald also discussed the advantages and benefits expected to be derived from the installation in the low-pressure stage of the giant Seeligson project under construction in Southwest Texas. Most important consideration in selecting the centrifugal compressors is extremely low maintenance and loss of operating time.

In their paper, "Significance of Fuel Sensitivity in the Performance of Motor Gasolines," E. J. McLaughlin, supervisor, engine fuels division, and J. A. Miller, research engineer, California Research Corporation, discussed the significance of the laboratory octane ratings on the performance of motor fuels on the road. The authors reviewed commonly used laboratory test methods, rating of various motor fuel blending stocks, and the meaning of the ratings in terms of road performances. The paper also contained a discussion of the methods of conducting road tests and the advantages and disadvantages of fuels of high and low senstitivity.

Roy M. Bauer, gas supply supervisor, Southern California Gas Company, reviewed the natural gas needs and reserves of California, which are becoming more acute daily due to the large increase in population of the state. Bauer stated that the majority of natural gas used in California in the future must of necessity be "foreign" gas. He pointed out the value of the La Goleta underground gas storage reservoir in meeting peak demands of consumers.

Bennett Is Speaker

E. O. Bennett, consulting engineer, Houston, delivered his paper on "Cycling at High Pressures versus Depletion and Cycling at Low Pressures," and attacked the idea that has been recently advanced that condensate-type reservoirs can be produced as efficiently if the reservoir pressure is allowed to decline to a low level before cycling operations are begun. Bennett stated that the economics of such an operation could not be justified, and in a hypothetical case showed that 87½ years would be necessary to sweep the reservoir of its recoverable liquid content if the pressure were allowed to drop before cycling operations were begun; whereas only 13 years were required if cycling was begun with development of the field. Also, he said that more wells would be required for low-pressure operations, than for high pressure.

Meetings

November
9-12—American Institute of Chemical Engineers, annual meeting, Statler Hotel, Detroit.
10-13—American Petroleum Institute, annual meeting, Stevens Hotel, Chicago.

December
1- 5—American Society of Mechanical Engineers, annual meeting. Atlantic City, N. J., Chalfonte-Hadden Hotel.
1- 6—21st Exposition of Chemical Industries, Grand Central Palace, New York.
12-13—American Chemical Society, Southwest Region, Houston.
29-30—Fourteenth Annual Chemical Symposium, American Chemical Society, Chicago.

January, 1948
12-16—Society of Automotive Engineers, annual meeting, Detroit, Book-Cadillac Hotel.

February
15-19—American Society of Chemical Engineers, regional meeting, New Orleans.

March
24-26—Natural Gasoline Association of America, annual convention, Ft. Worth, Texas Hotel.

April
5- 7—Western Petroleum Refiners Association, annual meeting, Galveston, Galvez and Buccaneer Hotels.
19-21—American Society of Lubrication Engineers, annual convention, Buffalo, Statler Hotel.
21-23—National Petroleum Association, Cleveland, Hotel Cleveland.
28-30—Liquefied Petroleum Gas Association, annual convention, Kansas City.

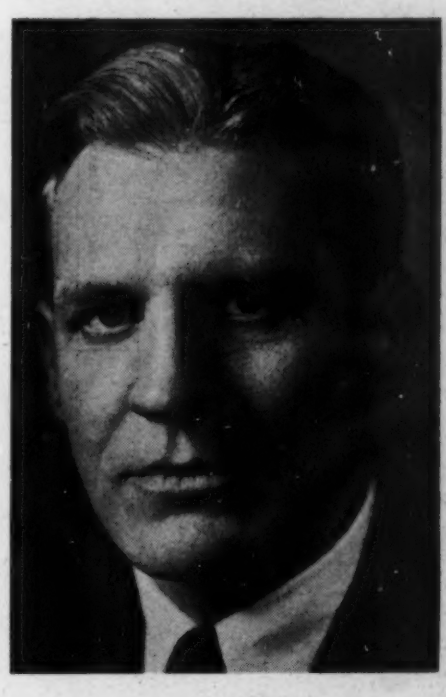
May
4- 5—American Gas Association, Natural Gas Department, Houston, Rice Hotel.
15-22—International Petroleum Exposition, Tulsa.
24-26—American Gas Association, joint production and chemical conference, Asbury Park, N. J., Berkeley-Carteret Hotel.

June
21-25—American Society for Testing Materials, annual meeting. Detroit, Book-Cadillac Hotel.

Hatch Named Manager of Aramco Manufacturing

R. S. Hatch has been named manager of manufacturing and processing for the Arabian American Oil Company.

Hatch, a native of Boston, was graduated from Massachusetts Institute of Technology in 1927. He entered the employ of The Texas Company the same year and since then has held various positions in the Company's Refining and Refining-Engineering Departments.



R. S. HATCH

During World War II Hatch served as chairman of the materials subcommittee for District One of the Petroleum Industry Committee and Since January, 1946, has been manager of The Texas Company's Purchasing Department.

Three Oil Industry Men On Atomic Advisory Group

Three men from the oil industry are included on a board of consultants which the U. S. Atomic Energy Commission has named "to pay particular attention

Refinery and Other Plant Construction

A NUMBER of revisions are contained in this month's "box score" detailing refinery and other plant construction projects. The "box score" first appeared in the August issue of PETROLEUM REFINER and since that time has become very popular. A number of suggestions have been received and these, together with other data sent in by readers, give promise toward making the compilation more and more complete as the industry becomes advised as to its purpose and intent.

Companies whose projects are not listed are asked to: 1) send in data on units not listed; 2) furnish details which are missing in the current tabulation and 3) report from time to time on progress of such work. Such helpful cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Agwi Pet. Corp.	Fawley, Eng.		120,000 bbls.	$140 million	Projected	1952			
Atlantic Ref. Co.	Philadelphia, Pa.	Propane, lubes			Under Constr.	Early '48	JUIK, Texaco	Badger	Badger
Bareco Oil Co.	Wichita, Kans.	Cat desul. & Ref.	7,500 bbls.	$500,000	Under Constr.	Early '48	Phillips	Koch Eng. Co.	Koch Eng.
Barnsdall Oil Co.	Benton, Louisiana	Gasoline plant			Under Constr.				Lummus
Caltex Pet. Maatschappij N.V.	Rotterdam, Holland	Crude plant	20,000	$18 million	Projected	Early '50		McKee	McKee
Carter Oil Co.	Billings, Mont.	Crude cat crk.	20,000 bbls.	$20 million	Under Constr.	1948		U.O.P.	Fluor Corp.
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	64,000 mcf	$19 million	Under Constr.	1948	Hydro-Res. Inc.,Texaco		McKee
Citcon Corp.	Lake Charles, La.	Lube Plant	6,000 bbls.	$30 million	Under Constr.		Texaco		Lummus, Max. B. Miller
Cities Service Oil Co. (Deleware)	East Chicago, Illinois	Modernize plant		$18 million	Under Constr.	Late '48	M. W. Kellogg	Kellogg	Kellogg
Cities Service Oil Co. (Deleware)	East Chicago, Illinois	Laboratory		$300,000	Under Constr.	Spring '48		Cities Service	Sumner-Sollitt
Consolidated Ref. Ltd., Consol.	Haifa, Palestine	Crude Plant	124,000 bbls.			By 1950	Lummus, Kellogg	Lummus	Badger
Continental Oil Co.	Billings, Mont.	Cat cracking	7,500 bbls.	$8.5 million	Contract signed	1949	U.O.P.	U.O.P.	J & L Supply
Continental Oil Co.	Denver, Colorado	Crude, cat cracking	7,500 bbls.	$4 million	Under Constr.	Fall 1948	Houdry Corp. & U.O.P.	Con. Oil Co., Lummus	Lummus
Creole Pet. Corp.	Amuay Bay, Venezuela	Cat cracking	60,000 bbls.	$70 million	Under Constr.	1950			
Egyptian Government	Egypt	Crude plant						Lummus	Lummus
Ethyl Corp.	Baton Rouge, La.	Manu. facilities		$20 million	Announcement				
Gray-Wolfe Co.	Montgomery Co.	Gasoline plant	13,000 mcf	$2 million	Under Constr.	Jan. 1949		O. L. Olsen	O. L. Olsen
Gulf Oil Corp.	Crane Co., Texas	Gasoline Plant	23,000 mcf		Under Constr.				
Gulf Oil Corp.	Port Arthur, Texas	Crude, Poly-Perco			Under Constr.	Early '48	Gulf-Phillips	Badger, Lummus	Badger, Lummus
Gulf Oil Corp.	Philadelphia, Pa.	Polyform			Under Constr.		Gulf-Phillips	Lummus	Lummus
Gulf Ref. Co.	Toledo, Ohio	Crude unit			Under Constr.	Earl '49		Badger	Badger
Humble Oil & Refg. Co.	Baytown, Texas	Lube plant		$5 million	Under Constr.	Early '48	Texaco	Badger	Badger
Humble Oil & Refg. Co.	East Texas	Gasoline plant		$2 million	Under Constr.			Fish Eng. Corp.	
Humble Oil & Refg. Co.	Katy, Texas	Propane, Butane Extraction	19,000 bbls.	$7 million	Contract let				Stearns-Roger
Humble Oil & Refg. Co.	Refugio, Texas	Gasoline plant	35,000 mcf	$2.5 million	Under Constr.	1948			Gaso. Plant
Kanotex Refg. Co.	Arkansas City, Kans.	Cat cracking	4,200	500,000	Contract let	Early '48	Phillips	Koch Eng.	Koch Eng.
Magnolia Pet. Co.	Beaumont, Texas	Lube plant			Under Constr.	Jan. 1, '49	Texaco	Lummus	Lummus
Magnolia Pet. Co.	Seeligson Field, Texas	Gasoline plant	90,000 mcf			Late '48		Hudson	
Fred M. Manning, Inc.	Stephens Co., Texas	Pres. Main	20,000 mcf	$500,000	Contract let	Jan. 48		Fish Eng. Corp.	
McCarthy Chemical Co.	Winnie, Texas	Petro-chem, Cat cracking	5,000 bbls.	¾ million	Under Constr.			Fish Eng. Corp.	
Mid-Continent Pet. Co.	Tulsa, Okla.	Vac still, cat cracking	45,000 bbls.	$8.5 million	Contract let	June '48	Phillips	Kellogg	
Monsanto Chemical Co.	Texas City, Texas	Rebuilding Petro-chem.		$6 million	Contract let		Kellogg		Kellogg
National Co-Op. Ref. Assn.	McPherson, Kansas	Cat Desul and Ref. unit	5,000	$400,000	Under Constr.	Late '47			Bellows Co., Leo Con. Co.
Ohio Oil Co.	Robinson, Illinois	Vac unit, cat cracking	27,500 bbls.	$15 million	Under Constr.	Late '48	Phillips	Koch Eng.	Koch Eng.
Petrol Terminals Corp.	Texas City, Texas	Cat cracker (recondition)			Under Constr.	Late '47	U.O.P.	McKee	McKee, Pritchard
Petroleos Mexicanos	Salamanca, Mexico	Crude, gasoil cracking	30,000	$12 million	Contract let	1949			Cat. Constr.
Plomo Co.	Nueces Co., Texas	Gasoline plant			Awaiting Appr'l				McKee
Porto Marghera R.	Venice, Italy	Enlarging							
Pure Oil Co.	Smith's Bluff, Texas	Lube plant		$9 million	Contract let				
Richardson and Bass	Keystone Field, Texas	Gasoline plant	70,000 mcf		Constr. approved	10-1-48	Texaco	Lummus	Lummus
Shell Chemical Co.	Thornton, England	Petro-chem.		Several millions	Under Constr.			J & L Supply	J & L Supply
Shell Chemical Co.	Shell Haven, England	Petro-chem.							
Shell-Chemical Co.	Stanlow, England	Petro-chem.							
Shell Chemical Co.	Houston, Texas	Glycol		Part $25 mln.	Under Constr.	Early '48			Kellogg
Shell Chemical Co.	Shell Point, California	Syn. Ammonia	45,000 mcf			Early '48			
Shell Oil Co.	Notrees, Texas	Gasoline plant		$4 million	Under Constr.	March '48		Brown & Root	Brown & Root
Shell Oil Co.	Houston, Texas	Lube unit	24,000 mcf	$10 million	Under Constr.		Texaco	Lummus	Lummus
Shell Oil Co.	Denver City, Texas	Gasoline plant			Under Constr.	1948			Fluor Corp.
Shell Oil Co.(Venesuela)	Cardon, Venezuela	Complete refinery			Under Constr.			Lummus	Lummus
Sinclair Ref. Co.	East Chicago, Illinois	Lube plant						Lummus	Lummus
Socony-Vacuum Oil Co., Inc.	Paulsboro, New Jersey	Crude, Lube plant	5,000		Under Constr.	Jan. 1, 1949	Texaco	Badger	Badger
Socony-Vacuum Oil Co., Inc.	Casper, Wyoming	Cat cracking			Under Constr.	Jan. 1, 1949			
Socony-Vacuum Oil Co., Inc.	East St. Louis, Illinois	Delayed coker and distillation	10,000			Jan. 1, 1949			Cat. Constr. Co.
Socony-Vacuum Oil Co., Inc.	Augusta, Kansas	Cat cracking				Jan. 1, 1949			
Socony-Vacuum Oil Co., Inc.	Augusta, Kansas	Cat cracking	12,000 mcf			Early '48			
Stanolind Oil & Gas Co.	Elk Basin, Wyoming	Gasoline plant	90,000 mcf		Approved			Stone & Webster	Stone & Webster
Stanolind Oil & Gas Co.	Slaughter, Texas	Gasoline plant	150 mcf		Approved			C. F. Braun	C. F. Braun
Stanolind Oil & Gas Co.	Hugoton Field, Kansas	Gasoline plant	100,000 mcf		Approved			J & L Supply	J & L Supply
Stanolind Oil & Gas Co.	Hugoton Field, Kansas	Gas syn plant			Announced			Hydro Res.	Kellogg, Foster Wheeler, Stone & Webster
Stanolind Oil & Gas Co.	Hugoton Field, Kansas	Chemical plant	130,000 lbs./yr.		Announced			Badger	Badger
Stanolind Oil & Gas Co.	Brownsville, Texas	Chemical plant	130,000 lbs./yr.		Announced			Badger	Badger
Stanolind Oil & Gas Co.			150,000 mcf		Projected	1949		J & L Supply	J & L Supply

Stanolind Oil & Gas Co.	Hugoton Field, Kansas	Chemical plant	130,000 lbs./yr.						Badger
Stanolind Oil & Gas Co.	Brownsville, Texas	Chemical plant	130,000 lbs./yr.						Badger
Stanolind Oil & Gas Co.	Pettus, Texas	Cycling plant	159,000 mcf						J & L Supply
Standard Oil Co. (Indiana)	Sugar Creek, Missouri	Cat cracking	25,000 bbls.		1949				Kellogg
Standard Oil Co. (Indiana)	Whiting, Indiana	Cat cracking	25,000 bbls.		Early '48				Kellogg, Lummus
Standard Oil Co. (New Jersey)	Linden, New Jersey	Vac, cat cracking, pipe still coker	90,000 bbls.		Early '48				C. F. Braun
Standard Oil Co. (New Jersey)	Baton Rouge, Louisiana	Lub Vac. still crude	90,000 bbls.		1949				Badger
Standard Oil Co. (California)	Richmond, California	Grease	82,000 lbs.	$5.2 million	Early '48		Texaco		Barrett & Hilp
Standard Oil Co. (Ohio)	Lima, Ohio	Cat cracking	6,000 bbls.	$10 million	Sept. '48		U.O.P.		McKee
Standard Oil Co.	Sweden	Crude, ther cracking			Late '49		U.O.P.		Lummus
Stora Kopparberg	Richland Parish, La.	Gasoline plant	70,000 gal.						Pet. Eng., Inc.
Sun Oil Co.	Duncan, Oklahoma	Crude plant	20,000 bbls.		Under Constr.		U.O.P.		
Sunray Oil Co.	Eagle Pt., New Jersey	Vac. still, cat cracking	40,000 bbls.		Under Constr.		Late '47		Kellogg, Foster Wheeler
The Texas Co.	Lawrenceville, Illinois	Crude and cat cracking	20,000 bbls.		Contract let		Late '49		Kellogg, Texaco Co.
The Texas Co.	West Tulsa, Oklahoma	Crude and cat cracking	30,000 bbls.		Announced		1950		Foster Wheeler
					Contract let		1949		Kellogg, Foster Wheeler
The Texas Co.	Port Arthur, Texas	Lube addition	2,000 bbls.		Under Constr.		Late '48		Foster Wheeler
The Texas Co.	Casper, Wyoming	Cat Poly Naphtha reformer, pressure coker	10,000 bbls.		Completed			Kellogg	Texas Co., Foster Wheeler
Winnsboro Ref. Co.	Winnsboro, Texas	Crude plant	3,000	$175,000	Under Constr.		Jan. 1, '48		Kellogg
Wood River Oil & Ref. Co.	Hartford, Illinois	Cat cracking, gasoil, cracking	8,500	$1 million	Under Constr.		Late '48		Mid-Continent
							Phillips		Koch Eng.

NOTE: Badger—E. B. Badger and Sons. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat Constr.—Catalytic Construction Company. Fluor—Fluor Corporation. Gaso. Plants—Gasoline Plant Construction Company. Houdry—Houdry Corporation. Hudson—Hudson Engineering Corporation. Hydro Res.—Hydrocarbon Research, Inc. J & L Supply—Jones & Laughlin Supply Company. Koch Eng.—Koch Engineering Company. Kellogg—M. W. Kellogg Company. Leon Constr.—Leonard Construction Company. Lummus—The Lummus Company. McKee—Arthur G. McKee Company. Phillips—Phillips Petroleum Company. Pet. Eng.—Petroleum Engineers, inc. Pritchard—J. F. Pritchard & Company. Stearns-Roger—Steane-Roger Manufacturing Company. Texaco—Texaco Development Company.

THE MONTH . . .

to the problem of development of useful power from nuclear energy." The three are Dr. Robert Wilson, chairman of the board, Standard Oil Company (Indiana); Paul Foote, executive vice president Gulf Research and Development Company; and Dr. Gustav Egloff, research director, Universal Oil Products.

The board, chairmaned by James W. Parker, president and general manager of Detroit Edison Company, would recommend methods of expanding industrial participation in the atomic energy project, as AEC Chairman David E. Lilienthal explained, "in line with our purpose of moving away from the present government monopoly provided by law just as fast as it can be done with due regard for national security."

Two New Directors for Houdry Laboratories

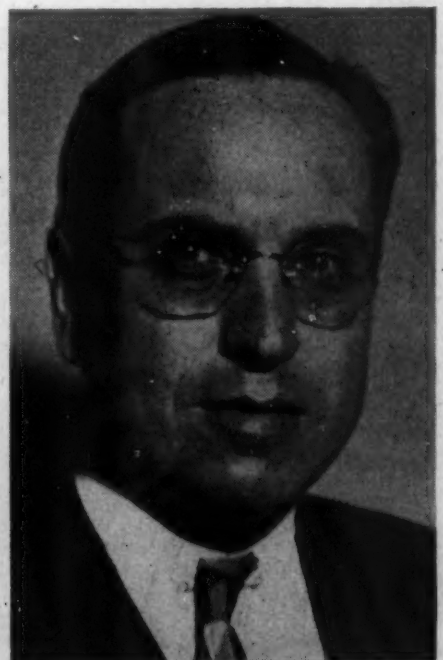
Dr. Alex G. Oblad and Jack C. Dart have been named director of chemical research and director of development, respectively, of Houdry Process Corporation Laboratories near Marcus Hook, Pa.

Doctor Oblad, a chemist with broad experience in the petroleum industry, has worked chiefly in the fields of hydrocarbon catalysis, chemical thermodynamics of hydrocarbons and physical methods of analysis. A graduate from the University of Utah where he also obtained his doctor's degree, his professional career includes research work with Standard Oil Company (Indiana), Magnolia Petroleum Company, and later as head of industrial research for the Texas State Research Foundation at Dallas.

Dart's academic training includes an A.B. degree from Albion College and bachelor and master degrees in chemical engineering at the University of Michigan.

His professional career includes employment with Pan American Refining Corporation, Magnolia Petroleum Corporation, and Standard Oil Development Company.

DR. ALEX G. OBLAD



JACK C. DART

Tomoconnor Field Plant Completion Next Month

Construction on the absorption-distillation facilities at the natural gasoline plant in the Tomoconnor field near Refugio, Texas, is going ahead and is scheduled for completion some time in December, it was announced last month by Humble Oil & Refining Company and Quintana Gas Company, the joint owners. When finished, the plant will strip about 60,000 gallons daily of natural gasoline, liquefied petroleum gas, and commercial propane from the wet gas.

Delivery of wet gas to the Tennessee Gas & Transmission Company system months before completion of the entire plant was commenced last month, officials said, in the interest of gas conservation. This was made possible by the early completion of the compressor section of the plant and the laying of by-pass lines to route the flow of field gas around the absorption-distillation facilities still under construction.

Operators' Cycling Plant For Bee County, Texas

Operators in the Burnell-North Pettus field have announced plans for a cycling plant to be located in Bee County, Texas. It will be operated by Stanolind Oil and Gas Company.

This plant is designed to handle 159,000 mcf per day of high-pressure gas and return 123,000 mcf per day to the formation. An additional 7000 mcf of casinghead gas now being flared will be processed and sold to United Gas Company, together with sufficient high-pressure gas to supply their requirements.

Design and construction is being handled by Jones & Laughlin Supply Company and actual field construction is expected to start next spring. The main

absorber will operate at 1600 pounds psi and gas will be injected at a maximum pressure of 3400 pounds. Approximately 7000 barrels of products will be produced daily including propane, butane, motor fuel, kerosine and fuel oil.

Corbett Named President Of National Grease Group

Included in the papers read at the national convention of the National Lubricating Grease Institute last month in Chicago were the following:

"Metallic Soaps" by S. B. Elliott, Ferro Chemical Corporation, Bedford, Ohio; "Grease Making, an Art or a Science?" C. L. Johnson, Jesco Lubricants, Kansas City, Mo.; and "Some Test Equipment for Greases," R. J. S. Piggott, president-elect SAE, Gulf Research & Development Company, Pittsburgh.

Reprints may be had from Carl E. Bolte, executive secretary, NLGI, 4638 Mill Creek Parkway, Kansas City 2, Mo.

J. R. Corbett, Cato Oil & Grease Company, Oklahoma City, was elected president to succeed H. P. Hobart, Gulf Oil Corporation, Pittsburgh. B. G. Symon, Shell Oil Company, New York, was named vice president; E. V. Moncrieff, Swan-Finch Oil Corporation, New York, treasurer and Bolte secretary. Six directors elected for a three-year period were Dwight F. Benton, Standard Oil Company (Indiana); Howard Cooper, Sinclair Refining Company, New York; C. B. Karns, Standard Oil Company (Pennsylvania), Pittsburgh; G. E. Merkle, Fiske Brothers Refining Company, Newark, N. J.; W. H. Oldacre, D. A. Stuart Oil Company, Inc., Chicago; and B. C. Voshell, Socony-Vacuum Oil Company, New York.

Holland Plant to Handle Crude from Middle East

Equipment for California-Texas Corporation's projected refinery in Holland (THE REFINER, October, 1947) will include thermal cracking and thermal reformer units. The plant will produce gasoline, kerosine, gasoil and fuel oils with marketing planned in Holland, Belgium and Luxemburg.

Designed to process Saudi Arabian crude, its completion in 1950 is timed with the date when additional Middle East oil will become available through the Trans-Arabian pipe line.

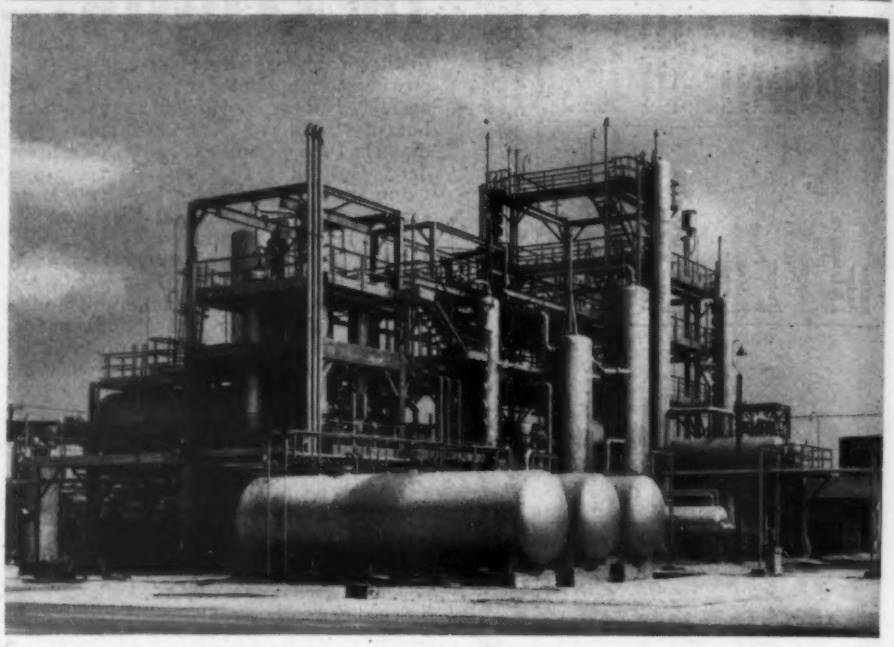
Contract for the engineering and construction of the refinery, except tanks, has been awarded to Arthur G. McKee & Company, Cleveland.

New Pennsalt Unit Installed at Wyandotte

Pennsylvania Salt Manufacturing Company has installed at its Wyandotte plant a unit for the manufacture of monochlorobenzene, a basic material used in the manufacture of DDT.

The MCB unit makes available by-products known as polychlors which can be used as a raw material in other chlorinated organics now under study in the Pennsalt Research Laboratories.

General Petroleum's New Plant Ready



General Petroleum Corporation's Torrance, Calif., refinery put into commission late in September a nominal 5000-barrels-daily Edeleanu plant. Total cost approximated $2,250,000 with construction and basic design features handled and supplied by E. B. Badger and Sons Company. Concerning the new unit, Gale L. Adams, assistant manager of manufacturing of General Petroleum, said: "Every effort has been made to incorporate flexibility in the types of charge stocks which can be processed and the range of solvent treatment which can be applied to each stock. In operations the solvent to oil ratio can be varied between limits of from ½ to as high as 2 to 1 with certain variations in the oil charge rate. Products range from solvents (both paraffinic and aromatic) through kerosine, agricultural spray oils, and diesel fuels. Diesel fuel of 50 octane number or higher can be produced."

Chemicals Represent Small Part of Petroleum Output

W. P. Gage, vice president of Shell Chemical Corporation, in an address last month pointed out that although petroleum provides raw materials for a large percentage of the country's synthetic ammonia and organic chemicals, the requirements for these uses represent only a minor fraction of the industry's potential supply. Under such conditions, he pointed out, alternative uses of petroleum hydrocarbons, such as gasoline components, liquefied petroleum gas, and domestic heating fuel, may be expected to fix the market value of petroleum for some time to come.

Speaking before the Texas Mid-Continent Oil and Gas Association at San Antonio, Gage stressed the difficulties of predicting future demands for chemicals, the markets for which are limited, uncertain and totally unlike those with which the oil industry is familiar. He stated, however, that the great potential over-supply of raw materials would have a strong tendency to hold petroleum chemical prices within a reasonable margin above bare manufacturing costs.

Ammonia production is at an all-time peak made possible by the extensive construction of plants during the war and by large postwar demand. Although 50 percent of all the ammonia is based on natural gas, the total gas requirements are less than one-quarter of one percent of the national supply.

The Fischer-Tropsch process for the synthesis of gasoline from natural gas yields by-product chemicals in quantities which are so large in relation to their respective markets, that in some instances they may not be absorbed at attractive prices. Even though they may glut their markets, according to Gage, their demands upon the natural gas supply will not be large enough to alter the over-all gas price picture.

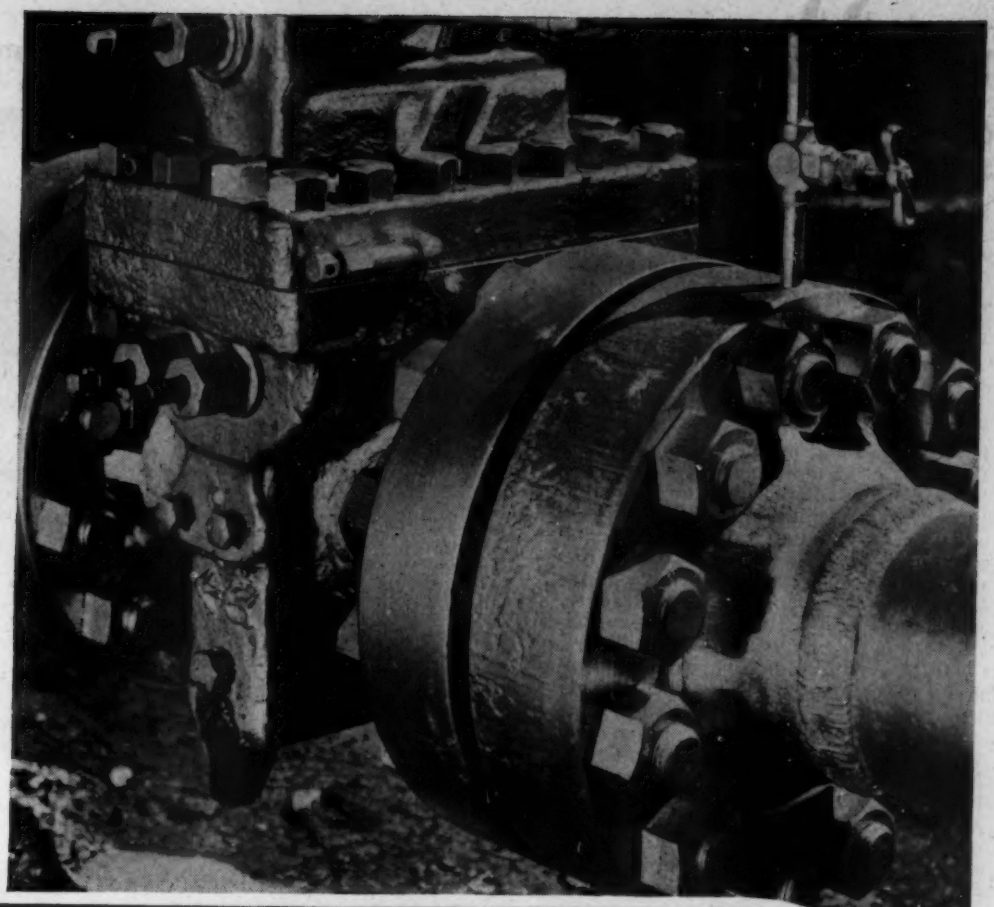
The manufacture of synthetic organic chemicals from petroleum, mainly from light gaseous olefins such as are obtained as oil refinery by-products from cracking processes, has reached the point where it accounts for more than 30 percent of total production, with coal and argicultural products being the principal competitive raw materials.

Ethyl's Fuel-Handling Shows May Continue

Since January of this year, five mobile units of Ethyl Corporation have travelled 87,374 miles to present their fuel-handling safety show before 21,000 executives and employes in nearly 400 refineries throughout the United States and Canada, Ethyl officials report.

The shows have been conducted by safety engineers assigned to Ethyl's four regional offices located in New York, Chicago, Tulsa, and Los Angeles. One concrete result of the shows, it is reported, is an increasing interest in the use of the air-mover in vapor freeing gasoline tanks. Copies of a pamphlet, "Safe Handling of Gasoline," have been distributed.

First scheduled to end this December, demand from many refineries for repeat performances may extend the tours into 1948. Future exhibits aimed at sales departments in addition to operations and engineering personnel, are being discussed by Ethyl's safety men.



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THE MONTH . . .

Oil Public Relations Job Said Making Good Progress

Completion of the first ten months' operation of the petroleum industry's public relations program finds more than 1000 companies, 2200 industry leaders and 40 trade associations actively participating in the program a few days ago. This is in accordance with a decentralized plan of operation adopted when 12 district organizations were set up.

The program of a nationwide organization to inform the industry itself of its public relations problems and setting the program in motion at the community level has now advanced to the point that more than two million pieces of editorial and advertising material have been distributed to tell the industry's story. Units originating their own plans have added everything from company tie-in advertising to floats in a rodeo parade expressing the theme of a progressive industry.

Oil company employe participation, active assistance of trade associations, use of speakers before groups in and out of the industry, local company advertising and radio announcements, exhibits at state fairs, etc., and advertising in nationally circulated magazines all have been given emphasis. And members of the Public Relations Operating Committee have expressed themselves as being highly pleased with the over-all results so far.

This fall and winter the district committees will urge their members to continue to gird for the task ahead, the bulk of carrying the industry story to the public at large. The indications are clear that this kind of effort will result in an increased understanding by all Americans of the oil industry's contributions to progress and to the national welfare, committee members declared.

Bay Petroleum Plants Are Adding New Units

New facilities for producing liquefied petroleum gas and improving gasoline quality were to have been put in operation November 1 at Bay Petroleum Corporation's refineries at McPherson, Kas., and Denver, Colo. Work at Denver is being done by the company's construction department whereas Refinery Engineering Company, Chicago, has the contract at McPherson.

The new equipment includes thermal reformer units, fractionating equipment and catalytic polymerization units.

Head of Warren Petroleum Cites LPG Industry Growth

Demand for propane, butane and other liquefied petroleum gases is rising steadily and present indications are that production of these products soon may equal the output of natural gasoline, W. K. Warren, president of Warren Petroleum Corporation, Tulsa, said last month.

"Until recently," Warren said, "the operations of the natural gasoline industry consisted mainly in the manufacture and distribution of the principal product of natural gasoline, and certain by-products of liquefied petroleum gases.

"Now the by-products, the most valuable of which, at the moment, are propane and butane, are equally important to the industry as natural gasoline, and before long, production and demand in quantity for liquefied petroleum gases may approximate the present demand for natural gasoline."

Warren Petroleum Corporation, during 1941, manufactured and marketed nearly 75 million gallons of LPG, while during 1946, this figure had grown to about 255 million gallons. For 1947, it is estimated that some 375 million gallons will be produced and marketed, he said.

Third Living-Cost Bonus

Houdry Process Corporation will pay a third cost-of-living bonus to employes of the corporation and its subsidiary, Houdry Process Corporation of Pennsylvania. The bonus will be equivalent to 16 percent of the basic compensation for the four-month period September 1 to December 31, 1947, inclusive.

No employe shall receive less than $100.

Indiana Standard Research Changes

DR. R. C. GUNNESS

DR. T. H. ROGERS

R. C. GUNNESS last month became manager of the research department of Standard Oil Company (Indiana) and T. H. Rogers director of research. J. K. Roberts, general manager of research, who recently was made a director of the company, will continue to have general supervision over all research department activities.

Dr. Gunness received his doctor's degree in chemical engineering from Massachusetts Institute of Technology in 1936 and served as assistant professor in the chemical engineering department at M.I.T. for two years before joining Indiana Standard's research staff in 1938 as a group leader. In 1945 he was made associate director of research, heading the process-design and pilot-plant division of the research department.

Dr. Rogers received his Ph.D. from Johns Hopkins University in 1917 and was granted the honorary degree of Sc.D. by Center College in 1941. He served in the Chemical Warfare service during World War I, and, after experience with the Bureau of Mines and the Du Pont company, joined Standard of Indiana's research staff in 1922. He became an associate director of research in 1938 and has been particularly active in research on gasoline, distillate fuels, and motor oils. Dr. Rogers is one of the scientists who received the Modern Pioneer's award from the National Association of Manufacturers in 1940.

Standard Improving Facilities at Segundo

Contracts to modernize certain facilities at its El Segundo refinery at a cost of approximately $2.5 million was announced last month by Standard Oil Company of California as follows:

J. A. McNeil Company, Inc., Los Angeles, for construction of a package shipping warehouse, barrel reconditioning plant and several other buildings.

Morrison-Knudsen Company, Inc., Boise, Idaho, for construction of five new railroad spur tracks.

Pacific Pipeline and Engineers, Ltd., Los Angeles, for installation of an eight-inch wharf pipe line.

Dual Car Fuel System Described by Holaday

A fuel system that would supply high-octane gasoline to an automobile engine at "critical" periods and normal fuel at other times was suggested last month by W. M. Holaday, director of Socony-Vacuum Oil Company labora-

tories, in a talk before the Detroit section of the American Society for Testing Materials.

Declaring that the petroleum industry wants to hasten the advent of high-compression automobile engines just as much as does the car industry, he at the same time recommended further studies designed to achieve better utilization of the mileage possibilities of present gasoline.

The speaker referred to the high-compression ratio and small displacement engine demonstrated last June by Charles F. Kettering, General Motors engine consultant, who said at that time the new engine would effect a saving of a billion dollars a year in the motorists' fuel bill but that it required much higher-octane gasoline than now is available.

ASME Selects Bailey As National President

E. G. Bailey of Easton, Pa., vice president of The Babcock and Wilcox Company, New York, has been elected as the next national president of the American Society of Mechanical Engineers. He with other new officers will assume duties at the end of the 1947 annual meeting, Atlantic City December 1-5. Bailey, who succeeds Eugene W. O'Brien of Atlanta as president of the ASME, is an authority on fuels, combustion and power developments.

Other officers elected include:

Regional vice presidents—Frank M. Gunby, associate of Charles T. Main, Inc., Boston; Paul B. Eaton, Lafayette College, Easton, Pa.; Thomas E. Purcell, Duquesne Light Company, Pittsburgh; J. Calvin Brown of the engineering firm of J. Calvin Brown, Los Angeles.

Directors-at-large — J. B. Armitage, Kearney and Trecker Corporation, Milwaukee; Abbott L. Penniman, Consolidated Gas, Electric Light and Power Company, Baltimore; William M. Sheehan, General Steel Castings Corporation, Eddystone, Pa.

Anderson-Prichard Sets Enviable Safety Record

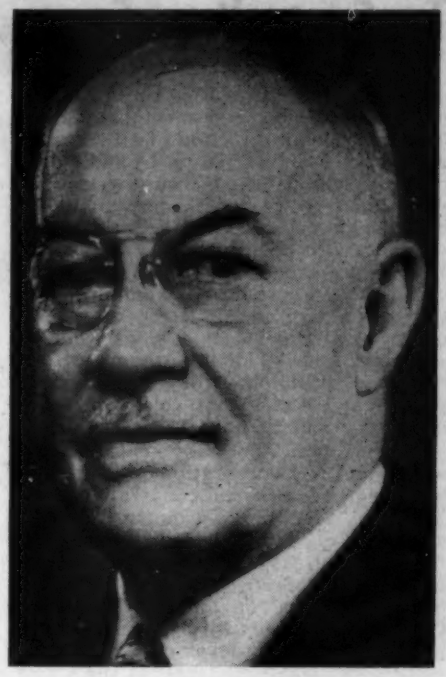
Anderson-Prichard Oil Corporation's refinery at Cyril, Okla., recently completed one full year of operation without a disabling accident, and the record is still continuing. Total man-hours worked since the last lost-time accident now exceeds 400,000.

The last lost-time injury ocurred October 16, 1946, when a worker suffered a broken collarbone in a freak accident. This accident was the only disabling injury incurred since May 19, 1945, which gives the refinery a record of 29 months, 888,000 man-hours with only one lost-time injury.

Regular safety meetings, inspections and training, plus the full cooperation of the foremen and workers are the main factors contributing to the safety record, according to W. L. Steiner, refinery superintendent.

All safety activities are conducted by Alec Vestal, safety engineer, under the general direction of the refinery superintendent, and John H. Scully, safety and personnel director.

Lion Oil Men at New Posts



T. H. BARTON

T. M. MARTIN

T. H. Barton, president of Lion Oil Company since 1929, has been elected chairman of the board of directors, and T. M. Martin, vice president since 1929 and executive vice president since 1939, was elected to succeed Colonel Barton as president.

Barton has been a pioneer in the development of the petroleum industry in Arkansas. After organizing the Natural Gas and Petroleum Corporations in 1921, he later served as president and director of the successor Natural Gas and Fuel Corporation, which position he left to assume the presidency of Lion Oil Refining Company (renamed Lion Oil Company in 1945). Barton, a World War I veteran, holds many positions of importance in the oil industry, including a directorship of the American Petroleum Institute.

T. M. Martin has been active in the petroleum business since 1923 when he was engaged in an oil brokerage business in Chicago. Later he served as general manager of Diamond Petroleum Company at Louisville, Ky., which became a part of the Mid-Continent Petroleum Corporation. In 1929 he was elected director and vice president of Lion Oil Company. He holds a number of offices with national and sectional petroleum groups.

Resumption of Operations at Palembang Refinery To Have Vast Economic Effects

Three important effects will come from recent resumption of operations of the largest American refinery in the Far East, Standard-Vacuum Petroleum Maatschappij's Palembang plant (PETROLEUM REFINER, October, 1947.) These are, according to H. A. Gibbon, general manager of SVPM:

1) It will provide additional supplies to help speed recovery of Asia's war-stricken people.

2) It will contribute to easing the serious worldwide petroleum supply situation. (Palembang's initial rate will be 20,000 barrels daily, will increase to 32,000 barrels daily by February, while its prewar capacity of 45,000 barrels daily will be reached later in the year.)

3) It will assist in the financial stabilization of the Netherlands Indies, where before the war the oil industry was second only to rubber as a revenue producer.

Prewar, Standard-Vacuum Petroleum Maatschappij employed approximately 11,000 persons, of whom more than 10,000 were local personnel. This figure should be topped when operations again reach a normal level, Gibbon said.

Before the war this refinery furnished about 50 percent of the total product requirements of Standard-Vacuum and its subsidiaries which market in China, Siam, Indo-China, Malaya, Philippines, Netherlands Indies, India, Burma, Ceylon, Australia, New Zealand, the South Pacific islands, and South and East Africa. With the South Sumatran oil fields and the refinery idle, these areas were dependent on other sources.

Reconstruction of the refinery, repair and reconditioning of the producing fields and pipe lines and partial rebuilding of the 1,200,000-barrel deepwater terminal at Tandjong Oeban, 30 miles southeast of Singapore, have also been accomplished in a year's time against heavy handicaps, Gibbon said. At the start of the refinery rebuilding program the circulation of three currencies—

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Dutch, Indonesian and Japanese—made exchange so confusing that workers were paid in foodstuffs and other commodities. Since these items were in short supply, the company initially could employ only about one third as many workers as it needed .The problem was finally overcome by imports from the United States and South America which to date total more than 7000 tons.

The company is restoring as rapidly as possible the community facilties enjoyed by its employes before the war. These include homes, hospitals, schools, restaurants, post offices, movies, clubs and other recreational facilties. In the severe battle against inflation, the company is helping by importing basic necessities and selling them to the employes at cost price or below.

Socony-Vacuum Receives First Middle East Crude

Middle East oil is coming to Socony-Vacuum Oil Company's Paulsboro, N. J., refinery for the first time, one cargo having arrived in October with two more due in November.

It was explained that one Kuwait cargo was purchased outright from Anglo-Iranian Oil Company while the other two were bought as a part of Socony-Vacuum's participating share from Arabian American Oil Company, this despite the fact that the deal by which Socony and Standard Oil Company (New Jersey) will acquire interest in Aramco is not yet completed.

Socony-Vacuum officials said this importation of Middle East crude was only a temporary expediency to relieve the company's current short position on crude; and that it was not economical to haul Middle East crude 8500 miles.

Government Is Offering German Chemical Plants

Additional reparations facilities for sale to United States industry announced last month include portions of the Dynamit A. G. Geestacht-Krummel and equipment from the Paraxol at Lippoldsberg, Germany, which will be sold independently of each other. The equipment includes units for production of formaldehyde, pentarythritol and plastics. Both plants are reported to be in good condition.

Inventories of these plants and information concerning inspection and bids may be obtained from the General Disposals Division, OFLC, 4th and Jefferson Drive, S.W., Washington 25, D. C. The closing date for sealed bids on both plants is December 10, 1947.

Ethyl Research Grants Expanded In Tenth Year

Continuing a program of aid in the field of college research, Ethyl Corporation has announced fellowship appointments to outstanding students in several fields. As participants in this year's program of awards established in petroleum, automotive, and chemical research, nine students have been chosen for graduate fellowships and one for a post-doctoral grant.

The post-doctoral fellowship, first of its kind offered by the company, has been established at the University of Cincinnati, for study under Robert A. Kehoe, director of the Kettering Laboratory and Medical Director of Ethyl Corporation.

Graduate fellowships, providing students with scholarship grants plus tuition, have been created thus far this year at the University of Michigan (2), Princeton University, University of Tulsa, Wayne University, University of Oklahoma, Louisiana State University, Purdue University, and University of Texas.

Texaco Personnel

A. M. Martin has been named superintendent of The Texas Company's Eagle Point Works, a new refinery being constructed outside of Philadelphia.

New faces at the Beacon Laboratories of Texaco includes Charles Winter, of New York, mechanical engineer; Irwin Frankel, formerly of New Orleans, chemical engineer in the chemical research department; and William R. Hencke, chemical engineer.

Cities Service Forms New Corporation To Centralize, Expand Research Work

Cities Service Research and Development Corporation, a new company, is to be charged with direction of all research which has been carried on by individual operating companies of Cities Service for more than 30 years, it was announced by Cities Service Company last month.

Along with centralization of activities will come expansion of research, the contemplated program extending into the realm of plastics, detergents, medicines, paints and lacquers, as well as synthetic fuels. The long-range project is to aid in supplementing the nation's petroleum resources, especially in times of national emergency, it was explained.

Among major development projects which the new corporation will direct is intensive research, in cooperation with The M. W. Kellogg Company, in the synthesis of liquid petroleum products from natural gas at both the Jersey City, N. J., plant of Kellogg, and the Cities Service refinery at Lake Charles, La. Others include intensifying and centralizing work on the development of automotive and household fuels at the Cities Service refineries at Lake Charles and East Chicago, Ind; the development of chemicals from natural gas at Tallant, Okla.; and the development of lubricants and greases at Ponca City, Okla.

The new corporation also will study the possibility of constructing a new research laboratory in the New York area as headquarters for the activities of more than 500 Cities Service chemists and scientific workers.

W. Alton Jones will serve as chairman of the board of the new corporation. A. P. Frame will be president; and C. L. Mateer, vice president.

Frame will continue in his present position as vice president of Petroleum Advisers, Inc., in charge of all manufacturing operations of Cities Service oil companies. In 1944 he took leave of absence from his job as vice president and chief engineer of Cities Service Refining Corporation, which built and operates the refinery at Lake Charles, and became director of the nation's oil refining for the Petroleum Administration for War. He continued in that capacity until the war ended. He is a native of Wallace, Nova Scotia, and joined the Cities Service organization in 1924.

A. P. FRAME

API's Organized Reserves Group Headed by Cummings

Carl E. Cummings, The Texas Company, Beacon, N. Y., has been named chairman of a permanent API committee to maintain liaison with the Army in a program for setting up oil industry affiliated units (Minute Men) of Army organized reserves.

API President William Boyd said the group, headed by Cummings, will function only as a contact and advisory board and that the Army will deal directly with such companies as it wants to sponsor units of working oil men for mobilization in an emergency.

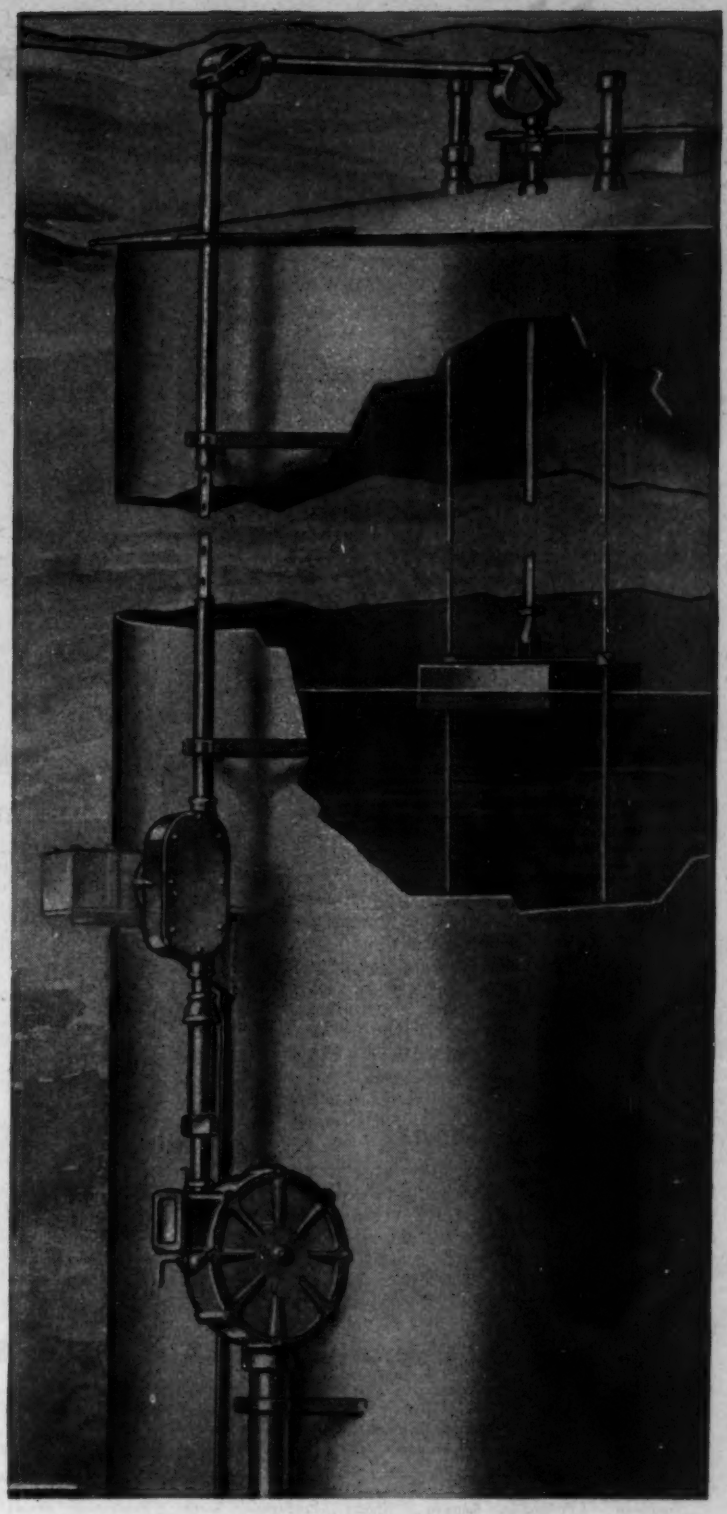
The new group will sponsor a session on organized reserves of Air Force, Army and Navy during the API meeting in Chicago.

Research Program Urged

Continuance of petroleum research to gain complete utilization of Pennsylvania crude oil was stressed in a statement last month by Carl H. Alsberg, manager of the Franklin Refining Division of L. Sonneborn Sons, Inc.

"Faced with declining stocks of Pennsylvania crude oil," Alsberg said, "it becomes exceedingly important for Penn-

LOOKING AHEAD—



Those who can anticipate the future many times save themselves considerable in cash and inconvenience. There are often good reasons why an entirely new program is not immediately adopted and completed. Sometimes it is judicious to lay the groundwork for what you see coming.

Judging from our own records, we note a definite trend toward remote gauging of tanks which will be another step ahead in safety, economy and accuracy. If we were the owners of a tank farm and interested in automatic tank gauging, but not quite ready to go all out for remote gauging, we would install the type of gauge used in the remote gauging system.

In the illustration at the right we show the type of automatic tank gauge employed in our Remote Reading Tank Gauge System. Minus the transmitter shown in phantom next to the sprocket housing, you have a regular ground reading automatic tank gauge with the addition of a sprocket housing. When you are ready for remote reading, you merely attach the transmitter, without having to change any piping or installing a new tape.

We suggest that you prepare now for the era of Remote Reading Tank Gauging.

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sylvania producers and refiners to accelerate their research programs so that new ways can be found to obtain greatest possible yields from Pennsylvania crudes."

New products "which will continue to guarantee the place of Pennsylvania crude as a premium crude, also must be found," he said.

Purchasing Department of Texaco Sees Changes

R. M. Morrison, general purchasing agent of The Texas Company since 1944, has been appointed manager of the company's purchasing department. He succeeds R. S. Hatch who goes to Arabian American Oil Company. Philip Hauck succeeds Morrison as general purchasing agent. W. G. Taylor replaced Hauck as divisional purchasing agent, Chicago, and F. G. Schlemmer of Los Angeles has been named northern divisional purchasing agent, New York, to succeed Taylor.

Ashland Likes Radar

Having proved the efficiency of radar in river navigation with its pioneering trials begun a year ago, Ashland Oil & Refining Company completed the installation of radar equipment aboard the last of its four larger towboats, the "Ashland," at the company's marine repair terminal, Catlettsburg, Ky., late in October.

In the first nine months of this year one of the company's craft operated 120½ hours in dense fog while all other nearby river traffic was stopped.

Formaldehyde Plant

Construction of a new unit at Springfield, Mass., to produce formaldehyde for expanded output of plastic resins was announced last month by Monsanto Chemical Company with completion slated for the second quarter of 1948.

Phillips Petroleum Add Research Men

D. E. CARR

DR. DAN FORE, JR.

Dan Fore, Jr., has joined the research department staff of Phillips Petroleum Company in Bartlesville, Okla.

Dr. Fore, a native of Mississippi, did his undergraduate work at Mississippi College, Clinton, Miss., and obtained his Ph.D. in chemistry from the University of North Caroline. He comes to Phillips from the Naval Research Laboratory in Washington, D. C., where he has conducted and directed research on fuels for Navy use.

D. E. Carr also has joined the research department of Phillips as a consultant on lubricants. For a number of years he has been with the Union Oil Company as director of research.

Carr, a native of California, received his scientific education at the University of California and has been particularly identified with the pioneer work on propane dewaxing and deasphalting, contributing a number of papers and patents in this field. He also has been connected with recent technical advances in the refining and utilization of petroleum waxes and the development of lubricating oil additives.

Progress at Old Ocean

Progress in stopping the practice of flaring natural gas was reported last month by Texas Railroad Commissioner E. O. Thompson who said the field superintendent of J. S. Abercrombie Company and Magnolia Petroleum Company had advised that all wells in the Old Ocean field, Brazoria County, are now flowing to plant. Thompson estimated that besides the gas saved by this elimination of Old Ocean flaring that 60 million additional barrels of oil and 12 million additional barrels of condensate would be recovered.

Atlantic to Make Propane

Under a contract with Phillips Petroleum Company, The Atlantic Refining Company will install propane recovery facilities at its Point Breeze refinery, Philadelphia. The long-term contract between the two companies covers manufacture, storage and distribution of butane. Phillips is to build 500,000-gallon storage and loading plant near Point Breeze.

Daugherty Refinery Expands

Plant facilities for a recently developed product called "hydronate" are being opened at Petrolia, Pa., by Daugherty Refinery, a division of L. Sonneborn Sons, Inc. The plant will produce a petroleum sulfonate which is soluble in water, a product with extensive applica-

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1946:									
January 26	4,626	4,553	220,544	13,622	101,737	5,720	29,498	8,411	39,722
March 2	4,726	4,779	229,430	13,871	104,462	5,888	25,148	8,634	38,441
March 30	4,425	4,684	224,994	13,896	104,715	5,337	28,240	8,738	37,746
April 27	4,672	4,685	224,443	14,228	99,631	5,568	30,466	9,204	39,404
May 25	4,759	4,857	222,214	14,322	95,769	5,463	32,973	8,908	43,368
June 29	4,957	4,854	223,883	14,500	92,333	5,325	37,762	8,828	46,447
July 27	4,926	4,896	223,756	14,535	88,626	5,817	44,316	8,217	49,517
August 31	4,833	4,901	225,672	15,405	86,813	5,374	53,858	8,357	53,037
September 28	4,778	4,829	221,903	14,538	85,854	5,450	57,903	8,158	56,914
October 26	4,720	4,758	221,184	14,863	84,623	5,710	65,499	7,728	60,872
November 30	4,795	4,707	225,119	15,145	88,371	5,228	66,062	7,672	58,647
December 28	4,713	4,968	226,111	15,604	93,126	5,931	58,941	8,181	53,427
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,357	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	8,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,876	5,732	36, 32	8,910	45,224
June 28	5,109	5, 9	236,221	16,070	91,8 6	5,90	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,097	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242
September 27	5,196	5,200	224,994	16,501	82,472	6,136	60,406	8,580	56,777
October 25	5,295	5,16	224,308	16,529	82,003	6,638	62,609	8,666	57,419

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tions in the manufacture of detergents.

Among the other new facilities put in operation early this month is a 50-ton sulphuric acid plant, which will increase the refinery's production of sulphuric acid to 100 tons per day, all of which will be used in the Petrolia plant.

Included among the plant's products are white oils, deodorized kerosines, petrolatums, petroleum sulfonates and micro-crystalline waxes.

Merger to Make Sunray Among Nation's Largest

Plans for the merger of Pacific Western Oil Corporation and Mission Corporation into Sunray Oil Corporation of Tulsa were announced last month. Tulsa will be the corporate home of the enlarged Sunray and offices now maintained at Reno, Nev., and Bayonne, N. J., will be consolidated there in the recently announced new 24-story office building to be constructed in Tulsa and in which Sunray is a principal stockholder.

The merger, when fully consummated in December, will put Sunray among the nation's first 20 oil companies with assets from $144 to $300 million.

Upon confirmation of the merger Sunray will own all of the capital stock of the Getty Realty Company, which owns and operates Hotel Pierre in New York City, and will also own approximately 59 percent of the stock of Skelly Oil Company. Also to be acquired by Sunray is approximately 30 percent of the common stock of Tide Water Associated Oil Company, negotiations for the sale of which are underway.

E. L. Hall Will Direct Gas Testing Laboratories

Edwin L. Hall, coordinator of gas production research and secretary of the general research and planning committee of the American Gas Association has been appointed director of the AGA testing laboratories at Cleveland and Los Angeles as of November 1. Hall succeeded R. M. Conner who is resigning because of ill health. Conner will be retained in the capacity of Laboratories Consultant.

Hall, a 1924 graduate from Ohio State University with a degree of bachelor of metallurgical engineering, joined AGA in 1945 as coordinator of gas production research. Last August, he was appointed secretary of the general research and planning committee whose new research program calls for the expenditure of $18 million for general, technical and domestic gas research over the next three years.

Sweeny Refinery Ready

Operations have commenced at the Alamo Refining Company's plant at Sweeny, Texas, K. S. Adams, president of Phillips Petroleum Company, announced late last month. Alamo, an 80-percent owned subsidiary of Phillips, bought the plant in June from WAA. J. S. Abercrombie Company operated it during the war. Crude for full capacity operation by the first of 1948 has been made available.

Thinks Petroleum Industry Should Take Lead in Peacetime Atomic Energy Research

A suggestion that major United States industries draw up their own plans for peacetime atomic energy research, development and application programs was made October 16 by Dr. Charles Allen Thomas, executive vice president and technical director of Monsanto Chemical Company, St. Louis. Before manufacturing and research executives of Socony-Vacuum Oil Company, Inc., Dr. Thomas advised the petroleum industry to set up a concrete atomic energy program and to seek permission of the Atomic Energy Commission (AEC) for its undertaking.

In similarily-prepared addresses, two research experts—painted an optimistic picture of the gasoline situation with respect to future motoring. They are T. A. Boyd of the research laboratories division, General Motors Corporation, Detroit, and P. C. Keith, president of Hydrocarbon Research, Inc., New York.

AEC has had little time to reflect on the commercial possibilities of atomic energy, Dr. Thomas said but "the control organization's attitude toward industrial programs might well be favorable at the present time."

"Nuclear physicists attached to a vast government research organization cannot take us by the hand and lead us into atomic developments," Dr. Thomas said, adding that it will require cooperation between scientists, engineers and business executives for atomic energy to serve as it should—as an industrial tool of enormous proportions.

In suggesting that industry "has sat itself down to await a go-ahead signal from the government," Dr. Thomas urged that "instead of waiting for such a green light each major industry should draw up its own plan." Leadership is needed, he said, for peacetime industrial applications of atomic energy in all fields including chemical, power and petroleum.

Although the attitude of the AEC toward industrial programs might be favorable at present, government policy in this respect can be determined only through a specific proposal, he said adding:

"I believe that industry should now take the initiative; and the petroleum industry, with its advanced techniques and enormous resources, would be a good one to start the ball rolling."

Boyd predicted that future automobile engines with higher compression than at present, coupled with higher-octane gasoline, can mean many additional miles per gallon of fuel, while Keith again disclosed prospects for "a gigantic synthetic gasoline industry which will have far-reaching ramifications."

The General Motors representative paid tribute to the petroleum industry for technological advances in finding, producing and refining petroleum, and for the fact that "the cost of gasoline today (excluding tax) is just half what it was 25 years ago."

After referring to a recently-developed automobile engine with new high-compression qualities which, it is claimed, can give gains or one-third or more in miles per gallon by comparison with a present-day engine of ordinary compression, Boyd asserted that this engine's octane requirements are "little if any higher than is represented by fuels which can be produced by practical processes now known."

"It seems natural, therefore, to expect that the compression of automobile engines and the octane number of gasolines are due to rise in the future," he predicted.

Fluor Corporation Lists New Managerial Personnel

Shirley E. Meserve, vice president and general counsel, has been elected president of The Fluor Corporation, Ltd., Los Angeles, this following the recent death of Peter E. Fluor. Meserve, admitted to the practice of law in 1912, has supervised Fluor's legal affairs since 1926, having been made a director of the corporation in 1937. His law firm is Meserve, Mumper and Hughes, Los Angeles.

SHIRLEY E. MESERVE

W. Earl Dunn, vice president and general manager, will serve Fluor as executive vice president; D. W. Darnell, vice president and chief engineer, was promoted to vice president and general manager; and J. Robert Fluor, manager of manufacturing, was named vice president and assistant general manager. James P. Wiseman, director of sales, and T. H. Seavey, manager of purchases, both were made vice presidents. Francis E. Fischer continues as secretary-treasurer.

Robert L. Merrick, assistant chief engineer, was elevated to chief engineer, and Foster M. Stephens, director of development, was advanced to assistant manager of manufacturing.

Fluor's board of directors consists of the Messrs. Meserve, Dunn, Darnell, J. R. Fluor, Wiseman, Seavey, Fischer and Fred C. Fluor.

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Secretary Krug Calls For Higher Refinery Output

The United States will be called upon to accelerate its rate of refinery expansion to keep up with petroleum demands, Department of Interior Secretary J. A. Krug pointed out last month in a report on the ability of this country to provide aid for Europe from our natural resources.

The estimated 1947 rates of petroleum production and consumption in the U. S. are at an all-time high, exceeding two billion barrels a year, he said. Despite this record production, localized shortages may arise this winter or later.

The present export rate of 159 million barrels, the report added, does not constitute a drain on American resources, since no less would be produced even if exports dropped.

This year's production, the report continued, is all that can be produced efficiently with present equipment and reserves.

Krug said he expected Europe's demands for American petroleum to decline with completion of the Trans-Arabian pipe line scheduled for 1950.

The report said American petroleum production can be increased only by enlarging discoveries, or by taking out oil at a higher rate than conservation practices would indicate.

"If production of crude does not expand," it continued, "the United States will probably have to increase its imports of crude petroleum, as domestic consumption is expected to continue very high over the next five years, reaching about 2.2 billion barrels by 1952."

Imports now are as much, or more, than exports, it declared.

U. S. refineries are operating at about 95 percent capacity, the unused 5 percent being obsolete or badly located, the report said.

"Any important increase in refining will require new capacity," it was added. "Expansion programs are now under way in this field, but the rate of expansion probably will need to be increased."

The localized petroleum shortages foreseen for the coming year will result principally from shortages of tubing, casing and pipe line, and inadequate transportation capacity, it was explained.

Discussing exports, the report said that since 1918 exports to all countries have ranged from 14 to 20 percent of total U. S. production, except in the depression years when exports were 10 to 11 percent of production. Currently, however, exports are estimated at less than 8 percent, and slightly below the level of imports in volume terms.

Of the exports last year, Europe took only about 3 percent of our total production. A large part of the dollar volume of exports to Europe consisted of lubricants.

"The logical source of petroleum for Europe will be the Middle East, where the greatest increase in output is expected," the report went on. "There sources already developed stand ready to deliver large additional amounts of crude petroleum as soon as transportation equipment is available to carry it away and refinery capacity to process it."

Majewski's Plan of Allocating Oil Due To Be Aired at National Council Meeting

A plan for allocating and distributing oil and supplies east of the Rocky Mountains, as suggested by B. L. Majewski, Deep Rock Oil Corporation, Chicago, early last month, has been transmitted by the Interior's Oil and Gas Division to the National Petroleum Council "for such consideration as it (and its OGD-proposed supply committee, when set up) may deem appropriate."

In addition to a presidential proclamation urging that consumers conserve petroleum products the Majewski program calls for:

1) Coordination of our petroleum transportation system east of the Rockies, including tankers, barges, tank cars, trucks and pipe lines to insure their most efficient use.

2) Scheduling the flow of crude oil and products in such a manner that after the military and Marshall plan needs are met, remaining supplies will be fully distributed on an equitable basis to areas east of the Rockies.

3) Appointment of a study group to recommend ways and means of maximizing the yield of distillate fuel oil at the expense of gasoline for the coming winter.

4) Appointment of another study group to recommend how the quantities of aviation and motor gasoline could be increased by lowering the octane of gasoline to, say, a maximum of 74 for housebrand and 78½ for premium grade.

Majewski's plan was disapproved by many in the oil industry.

W. W. Vandeveer, president of Allied Oil Company, Inc., Cleveland, viewed the proposal as a scheme that would lead to government control. Vandeveer contended that the most effective measure to obtain more distillates is narrowing the price between gasoline and fuel oil. He cited five reasons for his opposition to bureaucratic control of the oil industry as: the oil industry can do the job; government controls create nothing; there is no such thing as just a little bit of government control; the shortage is not general from the Rockies east; government control of an industry freezes production, markets, prices and closes the door to free enterprise.

Replying, Majewski disclaimed any desire of "wanting the government to come into our industry with both feet in either wartime or peace" and felt that "the question of maximizing distillate fuel yields at the expense of gasoline and the matter of invoking maximum octane numbers" will be studied by the suggested committee and its finding reported at an early date.

"I do not distrust my government when it desires to help industry to legally help itself," Majewski declared. "Therefore, I see no reason why the proposed committee cannot work with the OGD to the advantage of the consumer without getting the industry into any kind of a strait jacket . . . I am asking only for governmental approval of permissive cooperative action by the industry, alone—without government umpires to do certain approved specific things."

The matter doubtless will be aired at the NPC meeting to be convened in Chicago between November 10 and 15.

Regional Meets Scheduled By Natural Gasoline Group

Two regional meetings have been announced by the Natural Gasoline Association of America, one in the Herring Hotel, Amarillo, Friday, December 12, and the other in the Driscoll Hotel, Corpus Christi, late January or early February.

B. R. Carney, The Shamrock Oil and Gas Corporation, Amarillo, is program chairman for the Amarillo meeting with R. A. Schuster, The Chicago Corporation, Corpus Christi, chairman for the South Texas session.

According to NGAA President C. R. Williams, The Chicago Corporation, these regional meetings will take the place of the plant operators meetings formerly sponsored by the association.

Program for ASME Meet At Atlantic City Announced

New and coming developments in nuclear energy, rocketry, gas turbines, jet propulsion, fuels, safety, management and many other engineering fields will highlight the 68th annual meeting of The American Society of Mechanical Engineers scheduled December 1-5 at the Chalfonte-Haddon Hall, Atlantic City.

Speakers will include David Lilienthal, chairman of the Atomic Energy Commission; Fred S. McConnell, of Cleveland, president of the National Coal Association, on "The Coal Industry Looks Ahead"; Alvin E. Dodd, of New York, president of the American Management Association, who is to be awarded the Gantt Medal, on "Productivity, Prices and Markets"; and E. O. Shreve, president of the U. S. Chamber of Commerce and vice president of General Electric Company, New York.

Jennings Is Chairman of NPC Supply Committee

The National Petroleum Council's committee on petroleum products supplies and availability, set up on request of Interior Secretary Krug, will be headed by B. Brewster Jennings, president of Socony-Vacuum Oil Company with the following members:

Merle Becker, IPAA; Paul G. Blazer, Ashland Oil Refining Company; Bruce K. Brown, Standard Oil Company (Indiana); Stewart Coleman, Standard Oil Company (New Jersey); Gordon Duke, Southeastern Oil Company; James P. Dunnigan, Producers Refining Company, Inc.; R. G. Follis, Standard Oil Company of California; B. I. Graves, Tide Water Associated Oil Company; D. P. Hamilton, Root Petroleum Company; Walter Hochuli, The Texas Company; Harry J. Kennedy, Continental Oil Company; B. L. Majewski, Deep Rock Oil Corporation; D. A. Hulcy, Lone Star Gas Company; Clyde G. Morrill, Atlantic Coast Oil Conference; Frank M. Porter, Mid-Continent Oil and Gas Association; Sidney Swensrud, Gulf Oil Corporation; Reece H. Taylor, Union

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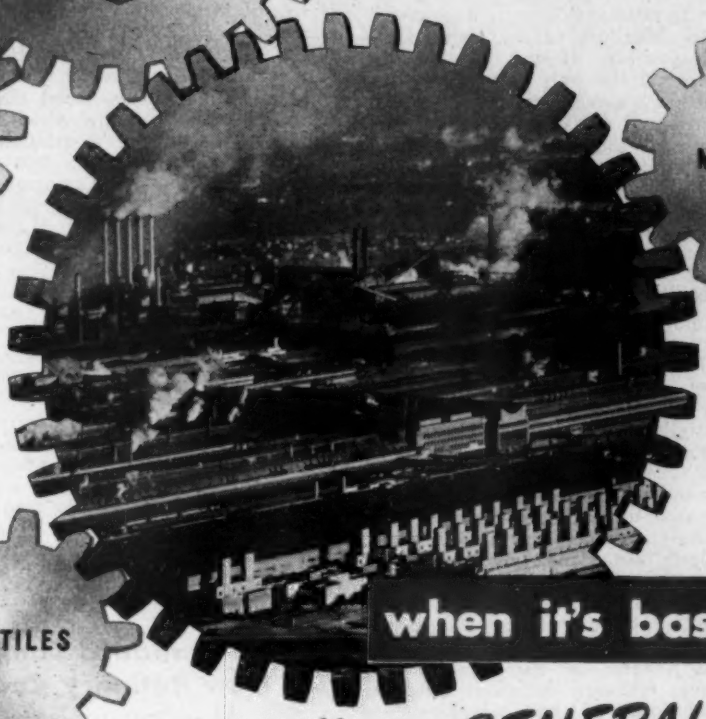

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Oil Company; W. W. Vandeveer, Allied Oil Company; L. S. Wescoat, The Pure Oil Company; and H. C. Wiess, Humble Oil & Refining Company.

Road-Test Laboratory Is Announced by Du Pont

A road-test laboratory, to test petroleum chemicals in motor fuels, is being established by the Du Pont Company at El Monte, Calif., with Iver Theodore Rosenlund, research engineer, laboratory manager.

Complete analysis tests, under actual

IVER THEODORE ROSENLUND

operating conditions, will be made on oils, diesel fuels and all types of gasolines, both chemically and physically. Particular emphasis will be put on the various products of the Du Pont Petroleum Chemicals Division, especially on tetraethyl lead compounds, which Du Pont will market directly to the oil industry beginning January 1, 1948.

Heavy-duty trucks were selected for the initial work, to start January 1, 1948.

Octane requirements of different types of vehicles will be studied and determined. The work will include testing new and existing products in present-day gasoline and future gasolines, and in determining effect of chemical additions to motor fuels, both in road performance and on the engines.

The laboratory will offer to do research work for oil companies which do not have sufficient facilities.

In addition to the Road-Test Laboratory, there will be a district service laboratory at El Monte—there is a service laboratory for each sales district in the nation—to offer technical service to the refining industry. Larger problems of refiners will be forwarded to the main laboratories of Du Pont where more complete facilities will be available.

Rosenlund, 33, a native of Worcester, Mass., came to Du Pont last March with broad engine research experience gained with several companies.

South Texas Chemical Engineers Program Drawn Largely from Oil Refining Problems

By L. D. DANIELS, Editor

The South Texas Section of the American Institute of Chemical Engineers in its annual technical meeting in Galveston on October 10, presented a program drawn largely from the oil refining and hydrocarbon processing activities of the area.

R. L. Bateman, manager of the fine chemicals division of Carbide and Carbon Chemicals Corporation, gave a paper, "The Synthetic Aliphatic Industry," with H. B. McClure of the same company as co-author. It was pointed out that until 1925 the only important tonnage synthetics were isopropanol and a few chlorinated solvents. Today the list includes 48 alcohols and glycols, 23 aldehydes and ketones, 23 acids and anhydrides, 33 esters, 4 ethers and oxides, 29 chlorinated compounds, 34 nitrogen derivatives, and 18 hydrocarbons. Annual production of these products now totals more than 6 billion pounds, not including alkylate gasolines.

Dr. Bateman mentioned many interesting compounds which have achieved industrial importance during the past few years. Included in his discussions were the polyalkylene glycols, allyl alcohol, ethylhexanol, the higher alkanediols, trioctyl phosphate, glyoxal, pentanedione, ethylhexoic acid, the vinyl ethers, new vinyl resins, acrylonitrile, alkyl ethonalamines, alkyl amines, the higher ethylene amines, melamine resins, polyethylene, butadiene, and isooctane.

Natural gas and petroleum have proven the most useful and economical sources of aliphatic materials. Germany, lacking these sources in sufficient quantity, was forced to use coal. As a result their research followed different paths and some of their developments such as the Fischer-Tropsch process, the Oxo process and the acetylene reactions postulated by Reppe are exciting interest in this country and may accelerate even the present rapid growth of the aliphatic industry.

"Modern Aspects of Mass Spectrometry" was the title of a paper by S. E. J. Johnson of Monsanto Chemical Company, Texas City. The principles of mass spectrometry had their origin in the work on positive rays by J. J. Thompson in 1913. Aston built the first positive ion sorter (mass spectrograph) in 1919 and shortly thereafter built a better instrument with which he identified the isotopes of neon. The field progressed rapidly after that until today we have mass spectrometers making analyses of higly complex mixtures in many laboratories. The utility of mass spectrometry is not restricted to the straight-forward analysis of mixtures but has been used in biological tracer work, measurement of appearance potentials, and detection of new materials in nuclear fission. Some notable progress has been made in adapting the mass spectrometer to the continuous recorded analyses of certain gas streams in the plant. The utility of such a system is obvious. The mass spectrum may also be observed on the screen of a cathode ray oscilloscope thereby allowing a visual observation of the stream composition.

Other papers presented at the meeting included "The Algebraic Theory of Distillation," by P. G. Murdoch of Texas A. & M. College, "The Functions and Responsibilities of a Plant Instrument Department," by J. G. Kerley of the Shell Oil Company, (see *Petroleum Refiner* for September, 1947), "The Selection and Use of Ejectors," by D. H. Jackson of Croll-Reynolds Company, New York; "High Temperature Measurement of Gases with Thermocouples," by W. L. Bolles of Monsanto Chemical Company, Texas City, and "Cooling Water Treatment," by M. C. Forbes of Pan American Refining Corporation, Texas City.

The last paper discussed the subject from a broad viewpoint which was well stated in the speaker's summary. Cooling water treatment is a matter of interest to designers, operators, and management because the savings from its use can be large, especially if through its use increased efficiency or capacity results and the overall operating factor of a processing unit is increased or maintenance reduced. Before treatment can be initiated the necessity for it must be demonstrated and the exact source of the trouble located. The normal difficulties in a water system are microbiological fouling, scale formation, and corrosion. All of these factors must be considered for they are seldom found singly. There are numerous methods of combatting each of these evils, and the most suitable one must be found. Once treatment is begun testing must continue to give assurance that the treatment is operating satisfactorily.

Jersey Standard Companies Set New Refinery Record

With the oil industry operating at its highest level in history to meet unprecedented demands for petroleum products, refineries of domestic affiliates of Standard Oil Company (New Jersey) processed 19,900,000 barrels more crude oil the first nine months of this year than during the corresponding period in 1946.

The average amount of crude oil run through these refineries during the three-quarter period was 704,000 barrels a day, compared with 631,000 barrels a day for the same period in 1946. This is the third successive year which the affiliates' plants have set a new annual record.

Chicago Section of ACS Announces Meet Program

The complete program for the joint meeting of the Chicago Section American Chemical Society with the Chemistry section of the AAAS, scheduled at the Drake Hotel, Chicago, December 26-28, has been announced.

The group discussing petroleum chemistry will meet at 9 a.m. and 2 p.m. Friday, December 26, in the West Room with S. B. Becker presiding and the AAAS symposium on "Mechanisms of Hydrocarbon Reactions" with Herbert C. Brown presiding, will meet Saturday, December 27, in Bal Tabarin at 9 a.m. and 2 p.m. Included on the latter program are the following papers:

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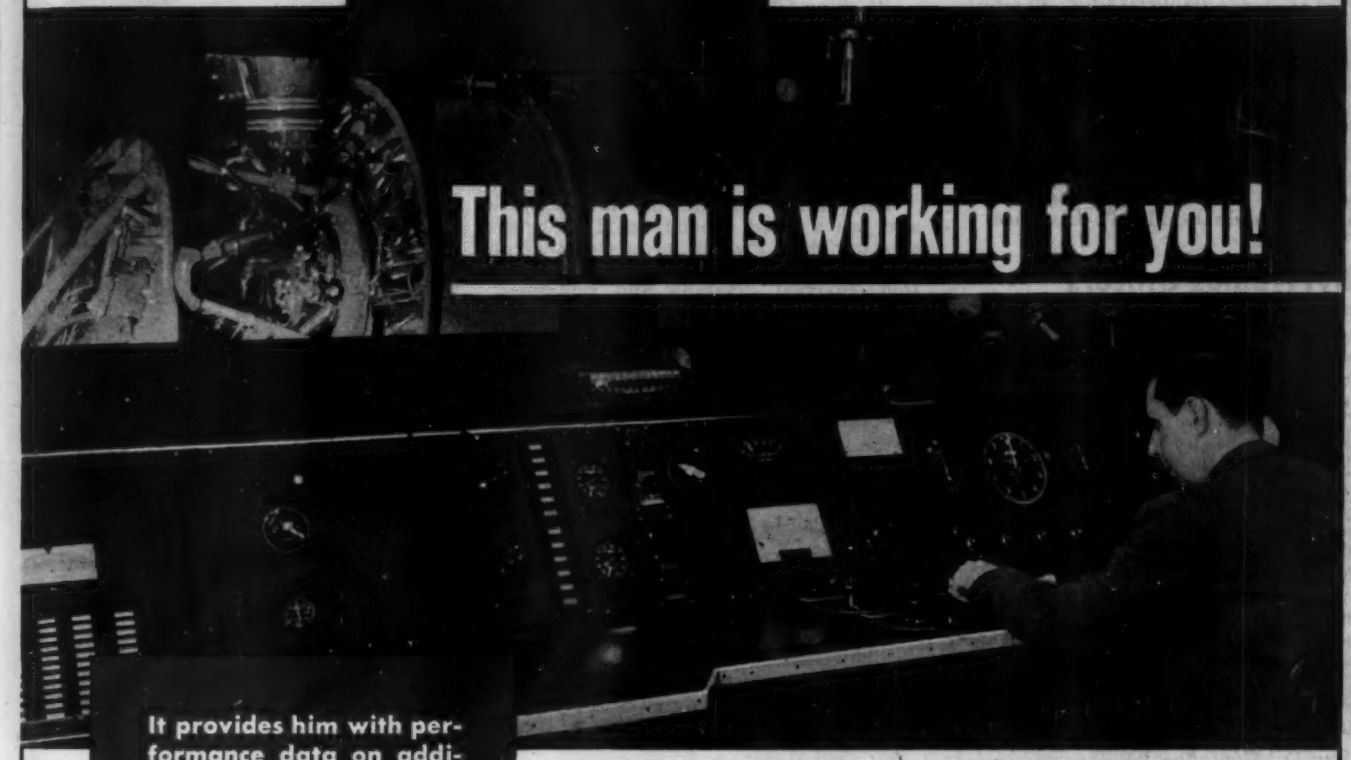

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rated Compounds," M. S. Kharasch and W. H. Urry. "Mechanism of Vapor-Phase Nitration of Hydrocarbons," H. B. Hass. "Effect of Chain-Branching on Reactivity," Herbert C. Brown. "Isomerization of Paraffins," B. L. Evering. "The Mechanism of Isomerization of Saturated Hydrocarbons," Herman Pines. "The Unitary Theory of Hydrocarbon Reactions," J. Turkevich. "The Mechanism of the Alkylation of Paraffins," L. Schmerling. "The Liquid-Phase Alkylation of Paraffins," A. W. Francis. "Mechanism Studies of an Alkylation Reaction," J. H. Simons. "The Addition of Aromatic Compounds to the Carbon-Carbon Double Bond," C. C. Price.

Ethyl Names Officers

Ethyl Corporation has announced election of Stanley T. Crossland, vice president and director, as treasurer, and Charles L. McCuen, vice president of General Motors, as a director.

Crossland, who succeeds the late Percy L. Griffiths as treasurer, joined Ethyl two years ago as comptroller and was elected vice president and director in June, 1946. From 1932 to 1945 he was associated, in various executive capacities, with the RFC.

McCuen became connected with Olds Motor Works in 1926 and last June was named general manager of the research laboratories division of General Motors to succeed Charles F. Kettering.

Sun Loses Plea

Sun Oil Company late last month lost its move to force the Department of Justice to specify in detail its accusations against Sun in the Mother Hubbard anti-trust suit.

The case is now expected to revert to an inactive status inasmuch as the Department of Justice has shown no inclination to bring the suit to trial, preferring instead "segment" suits rather than the old broad, general action.

Imports for California

California will be importing crude oil to meet its own needs within two or three years in the opinion of Robert L. Minckler, executive vice president of General Petroleum Corporation. He said an increase in the use of energy, attributed chiefly to industrial growth, has resulted in a 73 percent increase in demand for oil in California as compared with the prewar period.

Sinclair's Walsh Named

Joseph P. Walsh, general counsel of Sinclair Oil Corporation, has been appointed to membership on the American Petroleum Industries Committee of the American Petroleum Institute, William R. Boyd, Jr., API president, announced late last month.

Southwest Regional Meet

The Southwest Regional meeting of the American Chemical Society will be held at the Rice Hotel, Houston, December 12-13. Nationally prominent speakers will be on the program.

Expansion at Robinson, Ill., Plant of Ohio Oil Company Detailed by Manager

By R. E. LUTON,
Manager, Refining Division
The Ohio Oil Company

R. E. LUTON

The Ohio Oil Company recently inaugurated a program of expansion and improvement that will greatly increase the present capacity of its refinery at Robinson, Ill., the program including installation of a Fluid catalytic cracking unit.

The refinery operates on Illinois crude and has a rated capacity of 15,000 barrels per day. Present processes include atmospheric and vacuum crude distillation, thermal cracking and reforming, gas recovery, and catalytic polymerization.

Universal Oil Products Company will design and engineer the new units. The general contractor is Arthur G. McKee & Company. J. F. Pritchard & Company is constructing some of the offsite utilities, such as the water supply system, interconnecting piping, and power lines.

The new facilities will include: a two stage crude distillation unit of special design; a fluid catalytic cracking unit; a gas recovery plant; a UOP catalytic polymerization unit; and a treating plant for gasoline.

The general design and equipment used on the crude distillation plant represent the newest developments. The unit is designed for a capacity of 27,500 barrels of Illinois crude per day and includes facilities for atmospheric distillation, vacuum distillation, and oxidizing of asphalt.

The following fractions may be taken off the atmospheric side:

	Bbl./Stream Day
300°F. EP stabilized straight run gasoline	4400
300°-400°F. EP naphtha	3575
500°-530°F. EP kersosine	2750
625°F. Diesel fuel	2750
Gasoil	2750

Bottoms from the atmospheric side will be pumped into the vacuum column, where the following cuts may be taken off:

	Bbl./Stream Day
Vacuum gasoil	7370
Penetration asphalt	3130

The bottoms from the vacuum column may be used as flux or road oil, or they may be passed through the continuous oxidizer to produce asphalt of any desired penetration test. Continuous oxidation of asphalt is employed because a cleaner and more economical operation is thereby realized. To guard against corrosion, various alloys are used to line vessels that are subjected to any corrosive stocks.

New Fluid Catalytic Cracker

A new Fluid catalytic cracking unit, designed to use either microsphere or ground catalyst, will process gas-oil either on a high conversion recycle basis of 7500 barrels per stream day of charging stock or on a moderate conversion once-through basis of 12,400 barrels per stream day of charging stock.

In this improved design, placing the regenerator below the reactor permits reducing the size of the regenerator for a given capacity, marked reduction in length and diameter of catalyst transfer lines, dense phase catalyst transfer from the reactor to the regenerator, and a short regeneration air line to the regenerator. The catalyst recovery system consists of three stages of cyclones on the regenerator. The electrical precipitator used on earlier units for the recovery of catalyst fines is omitted.

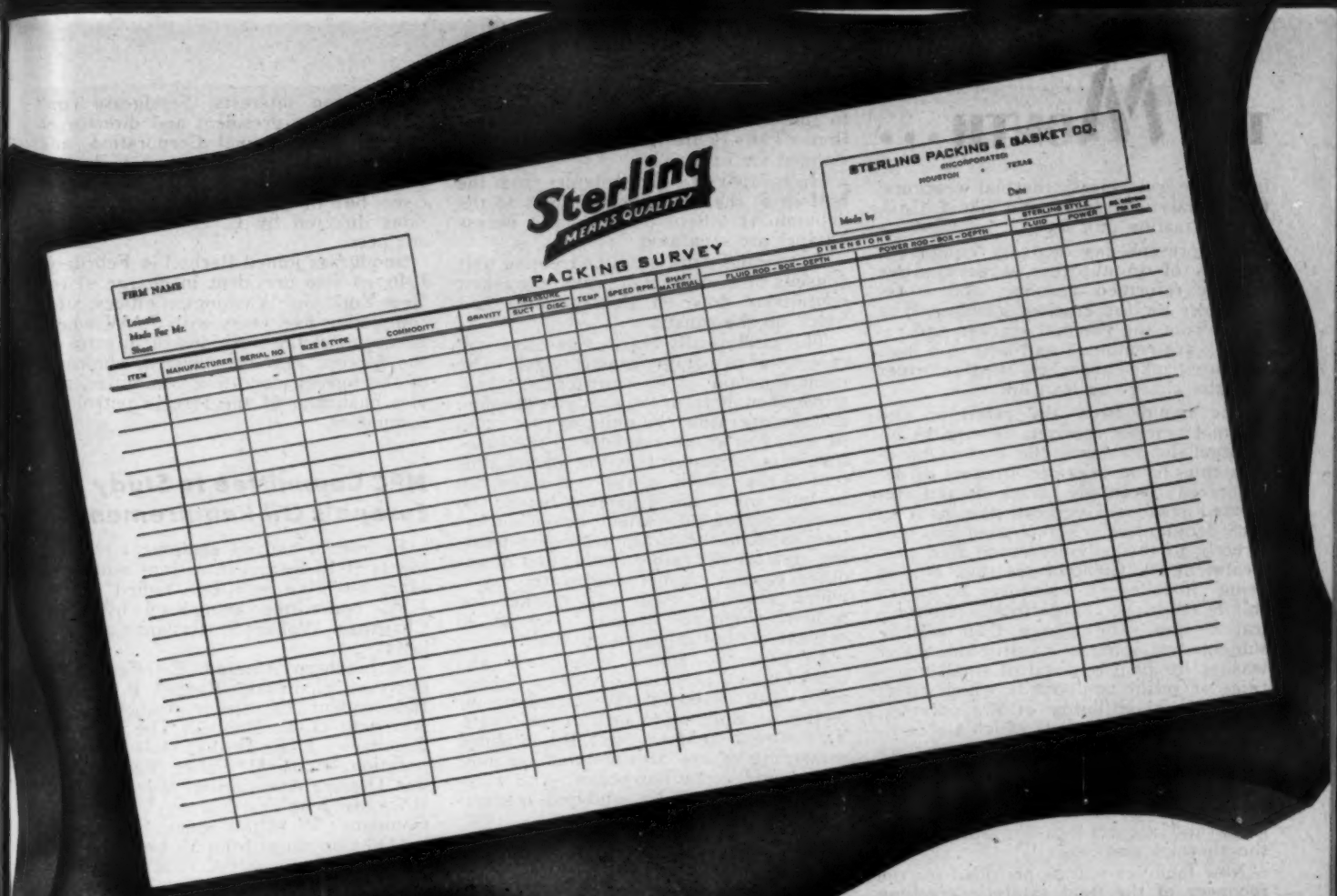
The reactor design includes dense phase horizontal grids, in addition to the main distribution grid, for reducing-catalyst recycling in order to prevent further cracking of cracked products, and to insure maximum gasoline recovery. Internal and external strippers are provided in the reactor for two-stage spent catalyst stripping.

Auxiliary equipment for the catalytic cracking unit includes a pressured slurry settler, fired charge heater, steam superheater for the high pressure steam from the flue gas steam generator and the main fractionator steam generators, gas-engine driven gas compressors, condensing turbo-blower, and special provision for minimizing erosion of the pressure control valve on the regenerator outlet and for silencing at the regenerator flue gas exhaust.

Detailed precautions have been exercised to minimize fire hazard; one feature is the installation of a permanent water fog spray system in the reactor-regenerator structure. Inspection and maintenance are facilitated by trolleys, hoists, platforms, and roadways which make all equipment easily accessible.

Gas Recovery System

The light gas recovery system has been designed to recover approximately 70 percent of the propane-propylene and 95 percent of the butane-butylene produced in the thermal and catalytic cracking operations. Products will be separate streams of debutanized gasoline



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from the reformers, thermal crackers, fluid catalytic cracker and liquid C_3-C_4 polymerization unit feed.

The present gas recovery equipment consists of an absorber, a debutanizer for the reformed gasoline, and a debutanizer for the cracked gasoline. The gases from the thermal cracker and reformer are combined and sent to a high pressure packed absorber, using reformer naphtha charge as lean oil.

The liquid from the reformer and thermal cracker receivers is sent to individual debutanizers, the bottom products thus being separate streams of debutanized thermally cracked and reformed gasoline. Overhead streams from each debutanizer are condensed and sent directly to the polymerization feed pretreatment. A Girbotol treating unit is being installed to remove hydrogen sulfide from the charge to the polymerization unit. The charge then will be subjected to separate caustic and water washes for final removal of small quantities of sulfur compounds which affect the lead susceptibility of the polymer, and nitrogen compounds which are detrimental to the life of the polymerization catalyst.

The vent gases from the debutanizers are combined with the main receiver gases and are sent to the absorber of the thermal units.

New facilities will be provided for the recovery of the fluid catalytic cracking unit gas. The unit will consist of two stages of compression, a high pressure absorber and a debutanizer.

The main lean oil stream for the high pressure absorber is made up of the liquid from the interstage receiver of the compressor system and the liquid from the low pressure catalytic cracking receiver. A sponge stream of 400° F. end point catalytically cracked naphtha from the main column will be charged over the top of the absorber to increase the recovery of butane and pentane. Debutanizer bottoms will be recycled over the main column as an additional absorption medium.

Fat oil from the absorber will be debutanized in the cracked gasoline debutanizer. The overhead will be combined with thermal unit stabilizer overheads and sent to the polymerization feed pretreatment unit. Vent gas from the debutanizer receiver will be combined with the second stage compressor gas as rich gas to the absorber. A common hot oil recirculating system is provided for reboiling all three debutanizers.

Catalytic Polymerization Unit

The polymerization unit will process 1500 barrels a day of high octane, polymer gasoline from 3800 barrels a day of charge stock. This charge stock will consist of debutanizer overhead from catalytic cracking, thermal cracking, and thermal reforming gas recovery units.

After being pretreated, the charge stock will be polymerized in high pressure shell and tube type reactors. The temperature of the catalytic reaction is controlled by boiling water around the catalyst tubes, thereby removing the heat of reaction. The generated steam preheats the feed stock. After pressure reduction, the reactor effluent flows to the depropanizer where the lighter hydrocarbons are separated and charged to the ethane column for LPG production. The lightest hydrocarbons are utilized for fuel.

High-vapor pressure polymer from the bottom of the depropanizer flows to the debutanizer where polymer and excess butanes are separated.

The straight-run gasoline treating unit consists of a single stage caustic washer, continuous flow on the gasoline, and batch on the caustic.

The catalytically cracked gasoline will receive a two-stage caustic wash. The main function of this treater is to remove phenols from the catalytic gasoline and, by operating the units so that caustic will flow countercurrent to the gasoline, it is estimated that the phenol content of the caustic in the first stage can be built up to 25-30 percent before the caustic must be discarded. Provision has been made in the catalytic gasoline treating area for the future installation of another caustic washer and water wash, which may be used if a market for sodium phenolate of the order of 40 percent concentration is obtained.

In order to insure stability of the cracked and polymer gasolines, equipment is provided for the immediate injection of inhibitor at each of the plants. To insure accurate control, the inhibitor measuring drums are mounted on indicating and recording scales. The polymer gasoline will be inhibited continuously on its way to storage.

New installations are expected to be in operation next summer.

Snodgrass Named Engineer Official with Bechtel

C. Stribling Snodgrass, a director of Bechtel Corporation, will now serve as vice president in charge of engineering, S. D. Bechtel, president, announced last month. Snodgrass will have charge of all engineering and development activities, with emphasis on the design and engineering of refineries and chemical plants.

In addition to his new duties with the domestic organization of the Bechtel construction interests, Snodgrass continues as vice president and director of Bechtel International Corporation, and as a director of International Bechtel Inc. He will headquarter in San Francisco, hub of Bechtel engineering operations directed by C. C. Steward, chief engineer.

C. STRIBLING SNODGRASS

Snodgrass joined Bechtel in February, 1946, as vice president in charge of the New York and Washington offices, after completing five years with PAW where he occupied the positions of director of the foreign refining division, chairman of the foreign operating committee, and vice chairman of the foreign petroleum committee.

NPC Committee to Study Europe's Oil Requirements

Petroleum and oil equipment requirements of 16 European nations under the Marshall Plan will be studied by an NPC committee announced by NPC Chairman Walter S. Hallanan, as follows:

A. Jacobsen, Amerada Petroleum Corporation, chairman; Russell B. Brown, Independent Petroleum Association of America; O. D. Donnell, The Ohio Oil Company; J. F. Drake, Gulf Oil Corporation; Louis M. Faber, Retail Gasoline Dealers Association, Milwaukee; B. Brewster Jennings, Socony-Vacuum Oil Company; W. Alton Jones, Cities Service Oil Company; John M. Lovejoy, Seaboard Oil Company; A. C. Mattei, Honolulu Oil Corporation; Geo. A. Hill, Jr., Houston Oil Company; Eugene Holman, Standard Oil Company (New Jersey); W. F. Humphrey, Tide Water Associated Oil Company; J. E. Pogue, Chase National Bank; Chas. F. Roeser, Roeser and Pendleton, Inc.; Robert E. Wilson, Standard Oil Company (Indiana), and Ralph T. Zook, The Sloan and Zook Company, Bradford, Pa.

Correction

In the A. M. Whistler article, "Effect of Leakage Around Cross-Baffles in a Heat Exchanger" which appeared in the October issue of PETROLEUM REFINER Equations 6 and 7 were interchanged at top of page 753. Immediately after Equation 5(a) the article should have read:

Equating surface equal to Heat/MTD/U, and rearranging we get

$$\frac{T_{n-2} - T_n}{D_n} = \frac{2S_i}{N} \frac{U}{WC} \left(\frac{R^{2/n} - 1}{\text{LOG}_e R^{2/n}} \right) \qquad (6)$$

But

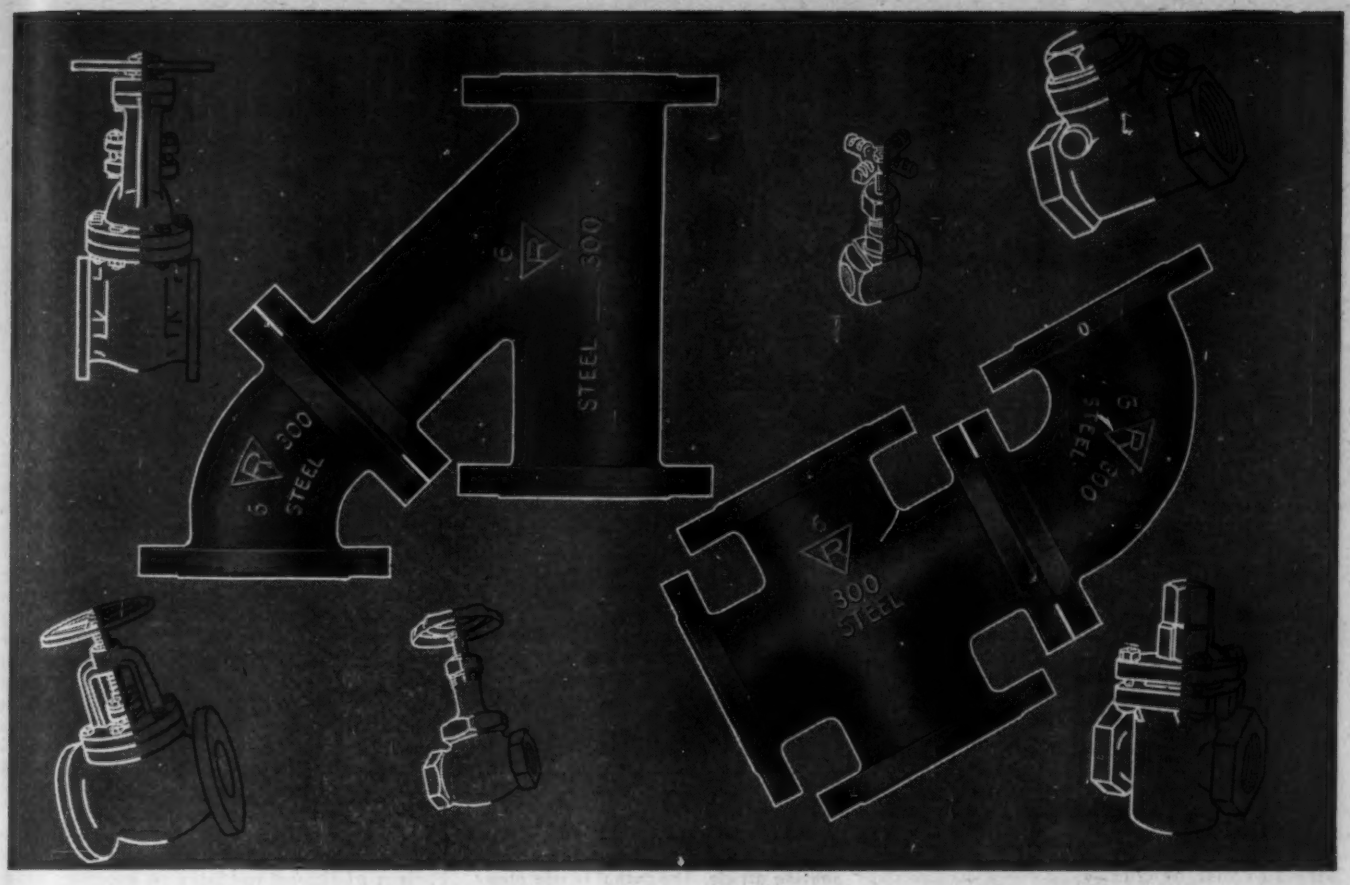
$$\frac{S_i U}{WC} = \frac{T_i - T_o}{\text{LOG MTD}}$$

So,

$$\frac{T_{n-2} - T_n}{D_n} = \frac{2}{N} \left(\frac{T_i - T_o}{\text{LOG MTD}} \right) \left(\frac{R^{2/N} - 1}{\text{LOG}_e R^{2/n}} \right) \qquad (7)$$

Those filing the Whistler article should clip and paste the above over the transposed version.

Also in the Nomenclature, R failed to appear in alignment with the other terms. $R = \frac{D_1}{D_o}$.



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Will Coal Help to Meet the Future Needs for Gaseous and Liquid Fuels?

By JOSEPH PURSGLOVE, JR., Vice President,
Pittsburgh Consolidation Coal Company

AREN'T we in the coal industry, you who comprise the gas industry, and all the oil interests of the country, faced with the need, in the public interest, of finding common ground on which we can work together? While I am aware of the difficulties involved in getting the government to understand the need for any such arrangement and to give its blessing, I believe that such cooperation offers the only real means by which that very important job of meeting the overall fuel and energy needs of the country can be accomplished.

A review of the whole national energy source picture was a factor in our company's formulating plans for research into converting coal into other usable forms of fuel, or energy.

Here are our findings as they pertain to coal: By including gasoline as an energy source, coal in 1945 made available about 54 percent of the country's total energy production. The divisions of all sources of energy, including gasoline, is shown in Figure 1. Coal supplied some 6 percent less of the total energy production as compared with ten years earlier. By excluding gasoline (as used in motor cars, airplanes and trucks), coal made available in 1945 about 61 percent of the energy required by industry and commerce, or a drop of about 7 percent since 1936.

Oil's Current Task

A look at conditions in the oil industry affecting present and future supply shows that at the peak of the wartime demand for oil (first three months, 1945), United States oil consumption for military, civilian and lend-lease purposes reached an all-time high of 5,358,000 barrels a day. Authoritative pronouncements were that with the return of peace this demand would taper off to some reasonable prewar level.

Today, however, in the face of unprecedented production and refinery activity, the oil industry is making a Herculean effort to meet a demand that has spiraled to average daily consumption of more than 5,870,000 barrels in the first three months of 1947—or more than most authoritative sources had estimated would be the daily requirements for oil by about 1960. It is estimated that the oil consumption for the first three months of 1948 will average 6,220,000 barrels a day, or nearly a million barrels a day more than the daily average peak of wartime consumption in 1945.

Is this present high demand for oil due to temporary conditions in the consuming markets? If not, does it mean that U. S. petroleum reserves are being exhausted at a rate which precludes the possibility of replacing the reserves at costs comparable with today's prices?

Our own investigation into this national energy source picture has turned up some seemingly significant data on both the demand situation and on the matter of crude reserves.

The over-all demand for gasoline dispensed from service station pumps is increasing as more and more automobiles are swarming onto the streets and highways. This demand is not likely to decrease in the foreseeable future. Also, a constantly greater use of trucks for freight handling can be expected to develop, so the demand for oil production to meet motor freight needs for gasoline cannot at this time be termed a temporary phenomenon.

THE role of coal in the drive for a nation's fuel is described in the accompanying article. The author is vice president of Pittsburgh Consolidation Coal Company whose company announced last spring plans for research expenditures "heretofore considered by coal industry standards as something akin to colossal." The accompanying article is slightly condensed from the paper which he presented before the American Gas Association's recent convention in Cleveland.

One of the big increases easily seen in petroleum consumption has come in the demand for light oils. More and more diesel locomotives are going to work on the railroads. This and a switch to oil burners for home heating accounts for a reported increase in light oil consumption of more than 65 percent over the 1941 figure. Finally, there is the very sizeable gain in consumption of gasoline and lubricating oils used by the airplane industry.

Thus, present-day requirement for oil is very probably what should be considered as representative of the normal demand for 1947, and this demand is likely to grow rather than diminish as the years pass.

Petroleum Reserves

In spite of claims and counter-claims on the subject of crude oil reserves, most oil men agree that the present market price of crude oil is below replacement costs. Here's one report on the matter: "Despite greater exploratory effort, increased and deeper drilling and improved technology, the estimates of reserves found each year are less than the annual civilian consumption." This may be too severe a statement, as figures indicate that reserves for the past three years are just about holding their own.

The gas industry, too, is confronted with problems for the future. You appear to have substantial reserves for the next few decades at least, this being particularly true in the Southwest. Transmission of the available surplus of this fuel to large consuming markets seems to present a problem to which, for the present at least, there appears to be no ready solution. A means of effecting a more satisfactory balance between low and peak load demands seems to be another real problem.

These particular phases of the gas industry problem, together with the problem of the oil industry in meeting growing demand, provide some basis for understanding the unusual interest evidenced in the possibility of making gaseous and liquid fuels out of coal.

Oil from Coal

How do we propose to do this job of making oil from coal? Following the synthesis method, we must first gasify coal . . . that is, convert it into carbon monoxide gas and hydrogen gas. This is exactly what you utility men in the gas manufacturing business have been doing for many years. Generally, you've made coke first in standard types of by-product coke ovens where you recover the tars and produce a coke oven gas of about 550 Btu per cubic foot. You then gasify the coke in more or less standard water gas sets making gas composed of carbon monoxide and hydrogen which averages about 300 Btu per cubic foot. You then crack up oil to enrich this water gas, thus bringing the mixture up to around 550 Btu per cubic foot of gas. This gas mixed with the coke oven gas is then put into the city gas mains. If you don't have coke ovens nearby or as part of your gas plant, you can buy coke, gasify it and enrich the gases by cracking oil.

We cannot afford to use the conventional water gas sets that make carbon monoxide and hydrogen gases. If we could sell gasoline for double or triple the present wholesale market price, that would be splendid.

Moreover, we can't afford the cost of the preliminary coking process. We must gasify the coal directly. We must gasify huge quantities of raw coal per hour in single retorts or vessels. All known present methods of gasifying coal directly are small, low-capacity units completely unsuited to our American fuel economy based as it is on large, high-capacity units. We are thinking of a relatively large commercial-size gasification vessel

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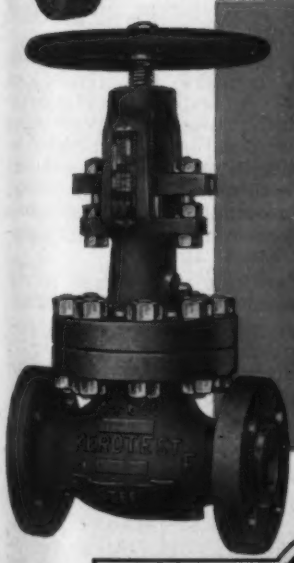

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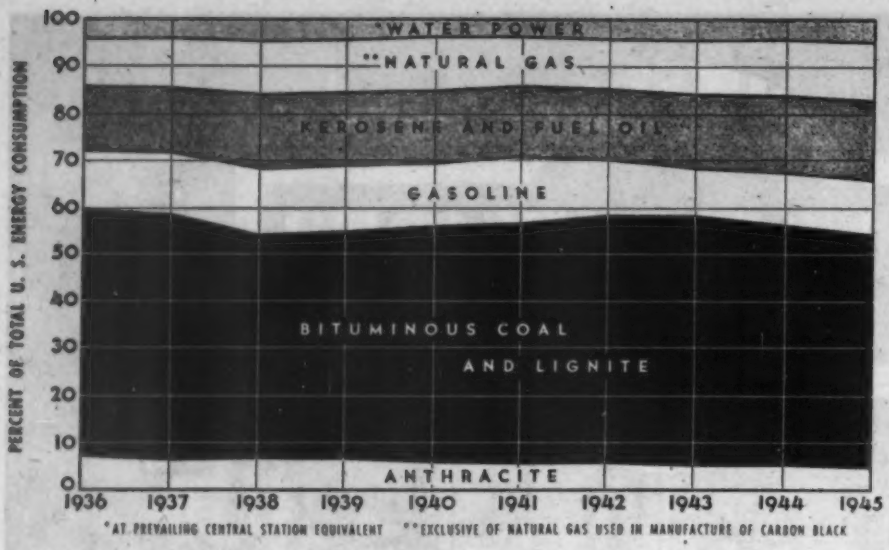

U. S. Energy Consumption in Terms of Btu Equivalent

in which a bed of fine coal is fluidized by a current of steam and oxygen (or air) passing up through the bottom of the vessel. Such a vessel might consume several thousand tons of coal every 24 hours and would produce many, many millions of cubic feet of carbon monoxide and hydrogen gases a day; probably in multiples of hundreds of millions of cubic feet. These are astronomical figures when compared with present day performances of a modern gas generator using coke or coal.

We are about to build a large-scale pilot plant near Pittsburgh to explore the possibilities of making gas out of coal on such a vast scale. The investment and cost of operating this pilot plant experimentally will be many millions of dollars.

In a possible future commercial plant these synthesis gases are scrubbed of impurities such as sulphur and are then carried into another large-size vessel called a synthesis reactor. In this vessel a finely divided catalyst is fluidized by the carbon monoxide and hydrogen gases that are bubbled up through the mass of catalyst particles. Most of the carbon and hydrogen atoms get together in this vessel to form liquid fuels. High-octane gasoline comprises more than 80 percent of these liquid fuels. The balance of the liquid fuels consist of diesel oils and light fuel oils.

Some of the oxygen atoms carried into this reactor with the carbon monoxide gas react with some of the carbon and hydrogen atoms and form a large number of commercial alcohols and some other chemicals. Also, some of the hydrogen and carbon atoms get together and form methane gas which is of high Btu value and this so-called tail gas could be made the equivalent of natural gas.

Coal Refinery of the Future

Now we have the completed picture. Coal comes from the mine; is crushed to a rather fine size and is then fed directly into the large gas generator where it is converted into carbon monoxide and hydrogen gas, leaving only the inert ash to be removed from the generator. This gas is cleaned so it's free of dust, sulphur, and other impurities and then is passed directlly into the synthesis reactor filled with a finely powdered catalyst. In this reactor, high-octane gasoline, diesel oil, fuel oil, alcohols and methane gas are formed. This is the coal refinery of the future.

I haven't mentioned any research plans of our company for the synthesis reactor end of such a coal refinery. Several groups and companies in the United States, for several years, have been working on the catalytic reaction of carbon monoxide and hydrogen. Pittsburgh Consolidation's partner in this coal gasification pilot plant project, Standard Oil Development Company, has operated a large scale synthesis reactor pilot plant at Baton Rouge, La., for three years. At this pilot plant, the raw material source is natural gas from the Louisiana fields. This natural gas is first broken down by partial burning into carbon monoxide and hydrogen. The carbon monoxide and hydrogen are then fed to the synthesis reactor where it forms into the same liquid and gaseous products mentioned previously as being formed in the proposed synthesis reactor part of a coal refinery.

All of the pilot plant work that has been done on the synthesis reaction of carbon monoxide and hydrogen is finally maturing into commercial applications. A large plant is being built near Brownsville, Texas, for the conversion of natural gas into gasoline, fuel oils and alcohols. Standard Oil Company (Indiana) has on the drawing board, I am told, plans for a similar plant in Western Kansas. Several other oil companies are reported to be planning to build plants in Texas to convert natural gas into gasoline. We feel, therefore, that by the time we have perfected a practical and commercial process for converting coal directly into carbon monoxide and hydrogen, the synthesis reactor half of our proposed coal refinery will be completely developed and matured.

Some of the Problems

What the long-time future holds for an industry of this kind only time can tell. What another great national emergency involving another global war would do in the way of foreshortening the time element required for the development of such an industry, can only be a guess. As for the thinking and planning of my own company today, we see before us an extensive program of research out of which we hope to obtain the knowledge of how to design a process that will work economically, and then to project this knowledge into the operation of the commercial plant. Even on this one plant basis, there are many problems, not the least of which is the matter of economics tied in with U. S. fuel trends and energy patterns.

There are a few naturally fortunate advantages with which we will work in maturing our own particular project. First is, that as the source material for a commercial coal refinery, there is available a block of coal large enough to sustain for a long period the operations of the size plant we envision. Equally important, this tract of coal is close to a large metropolitan county which is highly industrialized and in which the need for additional supplies of gaseous and liquid fuels may be developing while we are maturing our processes and plans.

While these advantages are being fully weighed, it seems clear that they will not offset the important factor of costs in delivering Btu's from such a plant to the consumer. All available means of projecting these costs at this stage of our development program support the belief that high-Btu gas could not be delivered into the mains of local gas companies at prices even close to those which now obtain for natural gas from the Southwest. Thus, the real usefulness (as a supplier of high-Btu gas) of our proposed program lies in having a plant sufficiently flexible in its operations that during summer months, for example, the bulk of the output would be converted into liquid fuels and in the winter months switched to production of gas. If this arrangement can be perfected, and we hope it can, gas from the coal refinery would then be available to augment the supply of natural gas at a time when the demand is at a higher than average level. And, it would be available at a time and under conditions when the local gas companies could justify the much higher cost of the coal refinery gas. To design and build flexibility of operation involving major changes in plant operation into a large coal refinery presents a research and development program of considerable magnitude.

As for the prospects of a nationwide oil from coal industry, the tremendous requirements in capital investments would have to be considered. We cannot estimate now just how much will be needed to place in operation the coal refinery we are thinking about. However, the amount would be much more than any one corporation could, in my opinion, possibly handle alone.

As to the position of coal and to the part coal seems destined to play in the future energy picture, there is an element of inevitability in its future role, if only because our nation is blessed with such large coal reserves.

Realizing that all of us in the energy and fuel fields must first consider meeting the public need, it seems important that we be conscious of the related horizons of the varied fuel and energy industries. There is a relationship in our objectives of service and also in the problems we must face and solve.

Troubled Waters for All

The future of the gas and oil industry will not be easy sailing and certainly so are there troubled waters ahead for coal, too. Important among these coal problems are the tremendously increasing

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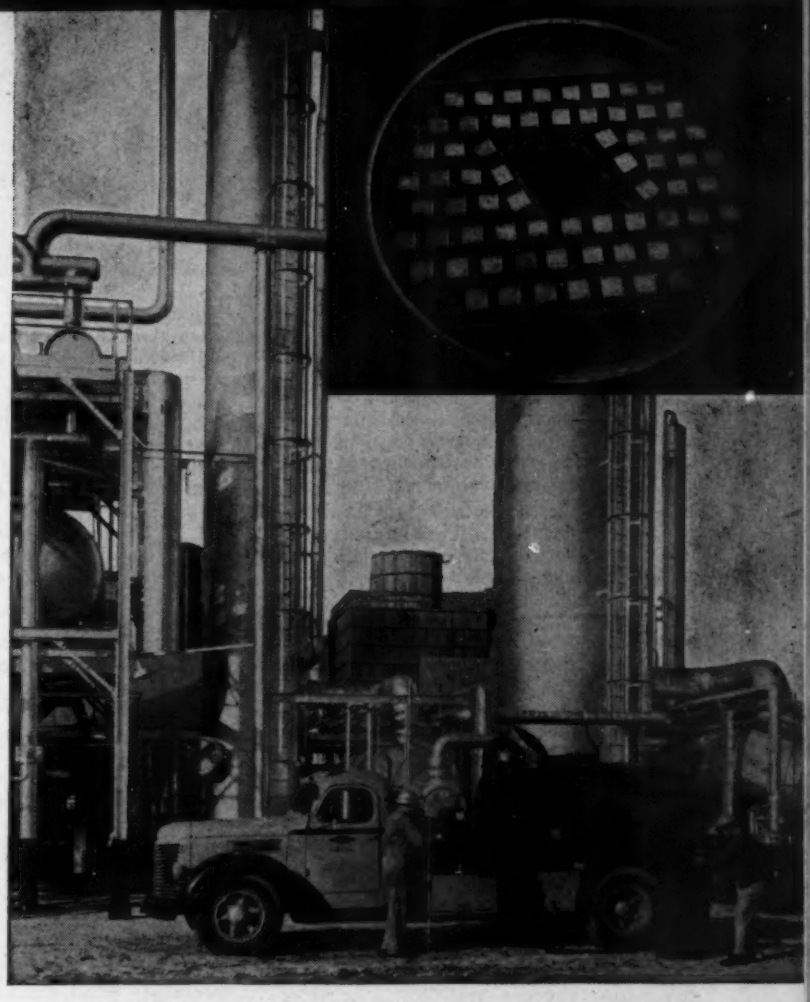

Successful application to bubble towers of Dowell's tested chemical cleaning method helps maintain tower efficiency—helps insure longer operating life for caps, trays, weirs, and for the tower itself. Dowell's rapid chemical cleaning has restored the designed operating efficiency in many, many plants—an achievement familiar to plant engineers who rely upon regular Dowell service to keep boilers, condensers and heat-exchange equipment free of scale and sludge accumulations.

Dowell service engineers do not require dismantling of the tower, or the erection of special scaffolding. They select the proper chemicals designed to dissolve and disintegrate the troublesome scales and sludges safely and quickly (usually in less than 24 hours). Liquid solvents are pumped into the tower, filling it to capacity . . . or are pumped in at the top of the tower and allowed to flow down over the trays. Dowell engineers bring adequate equipment to insure complete control and a good job—well done.

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capital costs and the ability of the industry to engage in long-range planning in the development of new production capacity in view of its past record of low earnings, if any.

The easily accessible coal deposits are being rapidly exhausted and new mines, to get into the deeper and otherwise more remote blocks of coal, are going to require much greater development costs. Mechanization of mining is now an absolute necessity, and it is a large factor in increasing the capital expenditures required for new mine development. A coal operator at the end of World War I could open a new mine with a few thousand dollars in cash. Then it cost less than one dollar per ton of annual capacity to get into the coal producing business. It now costs five to six dollars per ton of annual capacity, and this assumes that you already own a large enough block of coal to give sufficient life to the property to warrant such huge initial investments.

Moreover, the trend toward highly mechanized and costly coal producing operations accentuates the need for large and well-placed tracts of coal reserves. This also is a factor for increasing capital costs.

Capital Costs Increasing

It is important you understand that I'm talking of capital costs, and not production costs, because in the latter case there is still hope of reversing the trend through more efficient mining techniques and better national labor relations.

This matter of capital costs brings us to a consideration of financial health for the entire fuel and energy field. Just as the gas and oil industries are dependent on public capital and public regard, so coal is increasingly dependent on public good will and financial acceptance. The good financial health of a single element of the energy field is of benefit to the whole field. And beyond that, the financial health of the total energy field vitally affects the growth and soundness of our whole economy.

Hence, the need, in the public interest, of a common ground on which we can work together in the consideration of the broad energy problems. Hence, the need, in the public interest, of developing a new government concept of how this public interest can be better served through a cooperative attitude and relationships between coal, gas and oil as the major sources and suppliers of energy.

Fuel of the Future?

We cannot tell what the future will bring to us in the energy world. It may come to pass, for example, that coal will voluntarily yield to gas or oil in fields where gas and oil meet the need and still serve the broad aims of intelligent conservation and wise use. On the other hand, the time may come when you in gas or oil, will have to decide whether there are not certain energy applications better served by coal, thus freeing increments of gas and oil to do a better job in other consuming fields, all to the end that the American consumer is served at less cost. In any event, we do know with reasonable assurance that the need for energy in all its forms will grow . . . and all of us must grow if this need is to be met adequately and if we are to retain unfettered management of our roles in energy supply.

We believe the job of supplying this country's long-range energy requirements is too vast and complicated to be solved by any one group or combinations of companies in coal, oil, or gas. What, then, is the solution? I shall not undertage a specific and definite answer beyond the projection of these simple points: 1) the public need for fuel and energy must be a matter of first concern; 2) that we should begin to view that need jointly, and 3) keep before us constantly the necessity for developing government understanding of the magnitude of the job and that it will need to encourage rather than damn cooperative efforts among those who are to meet the challenge of a growing, progressive nation.

Our success in doing these things will largely determine whether or not free private enterprise shall remain free in America.

Sohio Veterans

Given official send-off on his tour of Toledo during the Sohio Quarter Century Club's annual meeting recently was Ben Hanna, a 50-year man with Standard Oil Company (Ohio).

C. C. Cleveland, at right, was re-elected to head the more than 1000 members of the club, which is limited to those with at least 25 years of service with the company and whose total now equals one in every 10 on the present pay roll.

H. H. Chapman (left) and his Toledo division of the club were host to the hundreds who journeyed from every city in Ohio to renew acquaintances.

Both Cleveland, of Lima Refinery, and Hanna, of Cleveland sales, started working with Sohio before the first service station existed in America. Next year, Hanna becomes eligible, at age 65, to receive the retirement annuity.

Philips Diffraction Course

Fall course in X-ray Diffraction and Spectrometry will be given from November 17-21 at the New York offices of North American Philips Company, Inc., at 100 East 42nd Street.

Purpose of the course is to acquaint industrialists, technicians and research specialists with fundamentals of X-ray diffraction and its applications. Lectures will be given daily, followed by laboratory work and question and answer periods.

Philips diffraction equipment owners will be admitted to the course without charge. Others will pay a fee of $50.

Invention Makes Possible Research on Rocket Fuels

Rocket exhaust flames believed to reach temperatures of as much as 4000° F. can be measured by a new device described at the Annual Meeting of the Optical Society of America, by Donald H. Jacobs, supervisor of the Long Range Navigation Section of the Aerophysics Laboratory of North American Aviation, Inc.

This new instrument has been named the "absorption-emission pyrometer" by Doctor Jacobs who has furnished this summary:

"A light source in the instrument sends a beam of light through the exhaust flame of the rocket and another beam of light from the same source is by-passed around the flame by a series of mirrors. A system of mechanical shutters causes these two beams of light to fall alternately upon a photoelectric cell. The photoelectric cell is connected to various monitoring, amplifying, and recording circuits. Studies of the theory of this device show that if the brightness of the light source is varied so that the photoelectric cell always receives the same amount of light from the beam that passes through the flame and the beam that passes around it, the temperature of the rocket exhaust will bear a known relation to the temperature of the light source.

"With this instrument it is possible to record automatically and continuously the fluctuations in the temperature of a rocket motor as the motor starts up and runs under various experimental conditions. Provision is included in the instrument for means of making a survey of the change in temperature across various cross-sections of the exhaust. It is not necessary that an instrument operator be in the vicinity of the rocket motor when it is running. Hence the instrument removes the problem of danger to operating personnel.

"This new instrument makes possible much research on rockets and rocket fuels that could not be performed previously."

Chemical Industries Exposition in December

Final preparations were being made early this month for the 21st Exposition of Chemical Industries which will hold forth in New York's Grand Central Palace December 1-6. Featured will be late developments in materials, methods and equipment for all phases of chemical processing, as well as technical assistance on present problems and future plans, officials declared. Exhibits will include a great variety of raw, partly manufactured or processed materials, machinery and equipment.

Fire at Borger

Two employes were killed and damage estimated at around $100,000 resulted from an explosion and fire early in October at Phillips Petroleum Company's Borger, Texas, refinery. Gasoline production, as a result, was curtailed for several days.

SCIENCE AND TECHNOLOGY ABSTRACTS

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Molal Refractions of Mononuclear Aromatic Hydrocarbons. NANCY CORBIN, MARY ALEXANDER AND GUSTAV EGLOFF, *Ind. Eng. Chem.* **39** (1947) pp. 1147-9.

The molal refractions of mononuclear aromatic hydrocarbons are additive in a homologous series, and can be expressed by an equation of the form R = k an, where R is molal refraction, calculated by either the Lorenz-Lorentz formula or the Gladstone-Dale formula, and n is the number of carbon atoms. Constants a and k were evaluated by the method of least squares for fourteen homologous series of mononuclear aromatic hydrocarbons. Molal refraction of hydrocarbons appears to depend primarily on bonding electrons. However, accurate determinations of molal refractions have shown significant differences between isomers, which indicate that structural factors have an appreciable effect on refraction. In general, the effect of structure on molal refractions is more pronounced among mononuclear aromatics than among the aliphatic hydrocarbons. A bibliography of 13 references is included.

Improved Method for the Interpretation of Experimental Data Obtained in Molecular Weight Determinations of Petroleum Fractions. J. G. REYNOLDS, *Jour. Inst. of Petroleum* **33** (1947) pp. 491-502.

The paper describes a method of interpreting data, obtained with the Menzies-Wright ebullioscopic apparatus, or by the cyroscopic technique, that eliminates the effects of errors in the zero reading of the Menzies differential thermometer or in the value found for the freezing point of the pure solvent. Apparent changes in boiling point or freezing point are plotted against the concentration of the solute, resulting in linear relationships in all cases so far examined. There is apparently no substantial departure from ideality of the solution within the limits of concentration covered by the data. The molecular weight of the solute is calculated from the gradient of the line so obtained, whether or not the latter passes through the origin. The method is illustrated by results obtained with a number of pure compounds, e.g., diphenyl, fluorene, and dicyclohexylbenzene, from which the ebullioscopic and cryoscopic constants for cyclohexane are calculated. Data from the experiments on two oils are interpreted by the recommended method and also by that involving extrapolation to zero concentration.

The Ten Dimethylnaphthalenes, Their Physical Properties, Molecular Compounds, and Ultra-Violet Spectra. A. S. BAILEY, K. C. BRYANT, R. A. HANCOCK, S. H. MORRELL AND J. C. SMITH, *Jour. Inst. of Petroleum* **33** (1947) pp. 503-526.

In the course of an investigation of the naphthalene homologues occurring in Trinidad petroleum, samples of the pure hydrocarbons were first prepared. Eight of the dimethylnaphthalene substances were studied; two were purified from commercial products. All of the compounds, except 2:7-dimethylnaphthalene, had been previously synthesized, but with conflicting results. Methods of synthesis used are described. Properties of the dimethylnaphthalenes are presented in tabular form.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Dodecamethylene dichloride
Octamethylene dichloride
Hexamethylene dichloride
Decamethylene dichloride
Tetrahydroxy stearic acid
Dichlorodimethyl ether
Dibromodimethyl ether
Trimethyl hydroquinone
Methyl-α-chloroacrylate
o-Hydroxymethyl-p-aminophenol
2,3-Dimethyl-1,3-butadiene
2-Methylheptadiene-1,5
Decadiene-3,7
3-Ethyloctadiene-1,5
3,4-diethylhexadiene-1,5
3-Chloropyridazine
Pyridazone
Pyridazone-3-carboxylic acid
Pyridazinone-3-carboxylic acid
Perhydrocyclopentanophenanthrene
1,1,1,2-Tetrabromoethane
2-Ethylhydroquinone
Isocrotonic acid

Chemical Composition and Reactions

Hydrocarbons in Petroleum. Hydrocarbons in the 102° to 108° C. Fraction of Petroleum. A. R. GLASGOW, JR., C. B. WILLINGHAM AND F. D. ROSSINI, *J. Research Natl. Bur. Standards* **38** (1947) pp. 621-6.

Careful study was made of a petroleum taken from a well at Ponca, Okla. The fraction studied was made aromatic-free by filtration through silica gel. Following preliminary distillation and blending, five distillations (regular and azeotropic) were performed at high efficiency and high reflux ratio. Samples could only contain ethylcyclopentane, 1, 1, 3-trimethylcyclopentane and 2, 2-dimethylhexane. Values of the first two compounds are tabulated. Properties are given of the material containing 2, 2-dimethylhexane, which was obviously not pure. The content of 2, 2-dimethylhexane was calculated to be 50% ± 10%. The total amount of the three compounds in the original crude oil was estimated as 1.4% by volume of the gasoline fraction of 40 to 180° C.

Alkylbenzenes from Benzene and Isobutene. I. Preparation, Identification of Several Fractions. D. I. LEGGE, *Jour. Am. Chem. Soc.* **69** (1947) pp. 2079-86.

Benzene was alkylated with isobutane in the presence of aluminum chloride. The hydrocarbons isolated from the hydrocarbon mixture were: *t*-amyl benzene, 1-isopropyl-2-*t*-butylbenzene, 1-isopropyl-3-*t*-butylbenzene, 1, 4-di-*t*-butylbenzene, 1-*t*-amyl-2-*t*-butylbenzene and *t*-octylbenzenes. The higher boiling material consisted chiefly of *p*-dialkylbenzenes. No tri-*t*-butylbenzene was found. *t*-Amylbenzene and 1-isopropyl-3-*t*-butylbenzene were formed when sulfuric acid was used as the catalyst. The possible course of the reaction is outlined on the basis of modern electronic concepts.

Alkylbenzenes from Benzene and Isobutene. II. 1,4-Di-*t*-butylbenzene. D. I. LEGGE, *Jour. Am. Chem. Soc.* **69** (1947) pp. 2086-90.

Although 1, 4-di-*t*-butylbenzene has been known for some time its chemical behavior has received little attention and definite proof of its structure has been lacking. The hydrocarbon was oxidized to terephthalic acid and its behavior towards electrophilic reagents was studied. The factors influencing the ready replacement of one of the *t*-butyl groups are discussed. New nitro,

no and bromo derivatives are described. ırrangement in the presence of sulfuric d leads to 1-isopropyl-3-*t*-butylbenzene.

Pyrolytic Dehydrogenation of Ethylnzene to Styrene. G. A. WEBB AND B. CORSON, *Ind. Eng. Chem.* 39 (1947) p. 1153-6.

The paper presents data on the relation f styrene yields to contact time and emperature in the absence of steam. Data for this noncatalytic conversion were obtained in order to have a measure for evaluating catalysis in the conversion of ethylbenzene to styrene. The efficiency of the pyrolytic dehydrogenation of ethylbenzene to styrene was determined at 700, 750, and 800 degrees C. at atmospheric pressure in the absence and in the presence of steam as a diluent. Operating with a 20% per pass yield of styrene, an ultimate yield of 55-60% was obtained, both in the absence and in the presence of steam. The apparatus used in the work is described. The methods of analysis are given. Within the range of experimental conditions used, steam was beneficial at 700° and 750°, but not at 800° C. In general, the presence of steam repressed the production of toluene. The formation of high boiling residue was favored by increase in temperature and contact time. Carbon formation (0.01 to 0.05% of the hydrocarbon feed) was too small under all conditions to be correlated with the effect of steam. A bibliography of 15 references is included and the data are presented in some detail in tabular and graphical form.

Manufacture: Processes and Plant

Circulating HTS as a Pilot Plant Heat Transfer Medium. WINFORD B. JOHNSON AND WESLEY M. NAGLE, *Ind. and Eng. Chem.* 39 (1947) pp. 971-4.

The use of heat transfer salt (HTS) as a heat transfer liquid in cracking plants has become fairly common. The salt containing 50 percent sodium nitrite and 50 percent potassium nitrate melts at 282° F. and is thermally stable and noncorrosive to steel up to 850° F. At higher temperatures the salt gradually decomposes with increase in freezing point, and stainless steel must be used to reduce corrosion. The present paper covers the actual experience gained in the operation of an oil-fired pilot plant furnace for heating HTS. A 50-50 salt mixture was pumped through a standard vertical, fire-tube type boiler made of steel. A heat transfer rate of 1200 to 2000 B.t.u./hour/square foot of boiler surface was obtained when the unit was operated at 600° to 850° F. salt temperature, thus giving a capacity of 200,000 to 400,000 B.t.u./hour for a boiler having a total heating surface of 203 square feet. The fuel efficiency was 50 to 55 percent without the use of economizers or waste heat boilers. The unit was operated for a total of 178 runs, equivalent to about 1500 hours. No unusual safety hazards were encountered. This pilot plant provides a convenient source of heat for general use in semiworks operations where the temperature required is above that provided by high pressure steam. In operation the unit is flexible, and standard types of air-operated temperature and pressure control instruments can be used to control the oil burner or to control a salt feed valve to an autoclave.

Estimating Installations of Chemical Equipment. J. R. BEHRENS, *Chem. Eng.* 54 (1947) Number 7, pp. 106-7.

The author discusses estimating for the plant engineer in a small or medium sized plant who does not have at his command the advantage of a special engineering division where facilities are available, including mechanical and chemical engineers, estimators, project engineers, structural and design engineers, draftsmen, and so on. The author discusses the preparation of an accurate estimate which requires all details and pertinent information with respect to the pump, the taking of enough time to do a good job, and finally lists miscellaneous factors that influence the cost of the project, as for example, safety, fire and service requirements.

Pressure Drop Through Packed Tubes. I. A General Correlation. MAX LEVA, *Chem. Eng. Progress* 43 (1947) pp. 549-54.

The work was undertaken to procure pressure drop data for many types of packing materials under a wide range of working efficiency and to correlate the data so obtained. From an analysis of flow of fluids through empty pipes, an equation was derived relating pressure drop through packed columns with the physical properties of the fluid and the dimensions of the apparatus. Experimental constant and the state of flow factor were evaluated by experiment the working equation was derived. Effect of each variable upon pressure drop was checked by experiments. The average deviation between observed values of pressure drop and values calculated by the equation given was ± 8 percent. The data used to substantiate the equation were obtained with homogeneous and nonhomogeneous spherical particles, cylinders of various ratios of height to diameter, and with metal rings. Containing pipes ranged in diameter from 0.824-3.068 inches. All particles used had smooth surfaces, such as glass or porcelain. For this reason the equation does not apply to particles with rough surfaces.

Heat Transmission from Fine Wires to Water. Low Velocity Data and Correlation. EDGAR L. PIRET, WALTER JAMES AND MAURICE STACY, *Ind. Eng. Chem.* 39 (1947) pp. 1098-1103.

In the studies of problems involving fluid flow, it is often desirable to measure low liquid and gas velocities without introducing an appreciable resistance to the flow of fluid. The hot wire anemometer is particularly adaptable for this purpose because of its small size and its ability to measure velocities well below the practical range of the Pitot tube. Unfortunately few data are available on the characteristics of fine wires at low water velocities. The present paper presents heat transfer data obtained on fine platinum and nickel wires at water velocities lower than previously reported, and for a relatively wide range of water temperatures and temperature differences. The data have been correlated by means of dimensionless groups and also by more readily solved empirical relationships.

Calculation of Theoretical Plates in Rectification. A. M. ESHAYA, *Chem. Eng. Progress* 43 (1947) pp. 55-60.

The method of calculation described has been tested in 79 examples involving both ideal and nonideal systems. The values found check closely with those obtained by the McCabe-Thiele method and by other methods. The procedure is applicable at reflux ratios greater than 1.10 times the minimum reflux. The procedure is faster and simpler to use than any previously available. Slide-rule accuracy is sufficient for all cases with the exception of ideal solutions with α less than 1.06. The method, although developed specifically for distillation, can be easily adapted to other mass-transfer operations.

Calculation Method for Complex Mixtures. W. D. HARBERT, *Ind. Eng. Chem.* 39 (1947) pp. 1118-24.

A method is presented for the calculation of vapor-liquid equilibria for complex mixtures. Computations are based on the true boiling point curve of the mixture and are performed by use of a plot of dM/dT_B vs. T_B. The procedures and equations used are similar to those in use for component mixtures. The results obtained are as exact as the data from which they are derived. Four examples are given of calculations involving a single equilibrium. The first of these is a calculation to determine the division of naphtha between vapor and liquid at equilibrium for given temperature and pressure conditions. The second is a calculation of dew and bubble point temperatures at 20 pounds per square inch absolute pressure. The third is the calculation of equilibrium flash curve and is calculated for a naphtha at 20 pounds per square inch absolute pressure. The fourth is an example of a somewhat more complicated calculation of the differential distillation curve for a naphtha. Data are presented in detail in tabular and graphical form and a bibliography of 18 references is included.

Catalytic Reforming. B. S. GREENSFELDER, R. C. ARCHIBALD AND D. L. FULLER, *Chem. Eng. Progress* 43 (1947) pp. 561-8.

Characteristics of certain molybdena-alumina and chromia-alumina catalysts were compared in terms of fundamental hydrocarbon reactions occurring in the catalytic reforming of petroleum naphthas. With pure hydrocarbons, the chromia catalysts are highly effective for the dehydrogenation of cyclohexane homologs and the dehydrocyclization of amenable aliphatic hydrocarbons to aromatics. When feed stocks such as petroleum naphthas are used, hydrogen pressure is required to suppress coke formation of the catalyst. Under hydrogen pressure, the molybdena catalysts are better from the standpoint of sustained high activity for the dehydrogenation of cyclohexane homologs and for their ability to catalyze other important reactions, including paraffin isomerization and dehydroisomerization of the homologs of cyclopentane to those of benzene. The paper includes points of interest in the industrial application of these processes, both for aviation gasoline and for toluene manufacture. Important secondary reactions of practical significance are described. Data on the catalytic reforming of certain naphtha fractions are given to support the work with pure hydrocarbons.

Testing of Cracking Catalysts. M. E. CONN AND G. C. CONNOLLY, *Ind. Eng. Chem.* 39 (1947) pp. 1138-43.

Cracking catalysts, like other catalysts, are susceptible to changes that may ap-

pear small and are often difficult to predict, but which have a large effect on results. Also it is desirable to have a method for evaluating the effects of preparation variables on catalytic qualities. The authors describe a fixed bed method of testing cracking catalysts and data are given to indicate how the test results were applied to show the effect of catalyst quality on yields in fluid catalyst cracking units. Cracking activity expressed as throughput for a given conversion is linear with surface area for catalysts of a given chemical composition. Carbon formation is increased when the catalyst has or acquires dehydrogenating properties. The advantages and disadvantages of various types of testing units are discussed. The equipment used is described in some detail and illustrated in figures. The fixed-bed test method described does not give results of high precision, but it has proved useful and contributed to the development of catalytic cracking.

Development of Hydrogenation and Fischer-Tropsch Processes in Germany. K. GORDON, *Jour. Inst. of Petroleum* **33** (1947) pp. 469-90.

The paper is the summary of what was done in Germany on the hydrogenation and Fischer-Tropsch processes. Developments of synthetic oil processes in Germany were undertaken as a part of their war program. Nothing was found by any of the investigating teams that differed materially from what was known before the war. The hydrogenation process was best developed from the engineering point of view. The Fischer process offers more scope for improvement. Manufacture of the synthesis gas by present methods is both expensive and not of high thermal efficiency. An improvement in gasification would be a big step forward. The synthesis process itself is also capable of great improvement. The Germans were working on alternatives to the tubular type of reactor, but had not advanced to the stage where anything was in large scale operation. The application of fluid catalyst technique might provide a satisfactory solution.

Performance and Design of Agitators. D. E. MACK AND V. W. UHL, *Chem. Eng.* **54** (1947) pp. 119-25.

The purpose of the work done was to present in simple, usable form, generalized correlations and design data obtained from literature and experience, and to show how they can be used to establish the design of a workable and reasonably-efficient tank and agitator system. Common problems are: contacting a gas with a liquid, increasing heat transfer from kettle walls or coils, and increasing mass transfer rate between solids and liquids, or between two immiscible liquids. Six typical design problems are considered. Agitator power requirement is discussed. Through the examples given the authors show how to design agitator systems either with or without pilot plant data, and to determine the performance of existing equipment when operated under changed conditions.

Products: Properties, Utilization and Analysis

Some New Extreme Pressure (E.P.) Lubricating Oil Additives Containing Chlorine and Sulphur. W. DAVEY, *B.Sc., Ph.D., F.R.I.C., Jour. Inst. of Petroleum* **33** (1947) pp. 527-30.

The condensation of chloral with mercaptans, in the presence of acid, gives trichloro-thioacetals which compounds show marked E.P. properties when blended in mineral oil. The compounds are active at low concentrations and the good E.P. properties shown are caused by the presence of a $Cl_3 . C —$ group. The E.P. properties of the compounds were studied by the use of the Four-Ball Machine. Results obtained suggest the value of combining both chlorine and sulphur in the form of a single additive. The ease of preparation of the compounds from petroleum mercaptans suggests the use of mercaptans that are generally regarded as objectionable when present in gasoline. The activities of the compounds in low concentration indicates their potential commercial usefulness.

Determination of Antioxidants in Gasoline. LOIS R. WILLIAMS AND BARNEY R. STRICKLAND, *Ind. & Eng. Chem., Analytical Ed.* **19** (1947) pp. 633-4.

Gasoline is treated with antioxidant compounds in order to inhibit the formation of gum and precipitation of lead and to maintain stability. Alkyl-substituted p-aminophenol and p-phenylenediamine derivatives are the compounds most commonly used as inhibitors of high potency. In treating gasoline with acid, alkali, or water, many inhibitors can be lost. It is therefore important to check the amount of inhibitor in the gasoline. This determination was of value during the war in studying the stability of aviation gasoline and is also useful in studying loss of inhibitor from gasoline. The procedure is a colorimetric technique based on extracting amino-, phenol-, or phenylenediamine-type inhibitors from gasoline with aqueous hydrochloric acid solution. The hydrochlorides of the inhibitor compounds are formed. When the extract is neutralized with sodium carbonate in the presence of phosphotungstic acid solution, a blue coloration is produced that the intensity of which is proportional to the concentration of inhibitor present in the gasoline. The procedure is described in detail and the results of typical analyses are given.

Assembly and Testing of 52-Foot Laboratory Adsorption Column. BEVERIDGE J. MAIR, ANDREW L. GABORIAULT AND FREDERICK D. ROSSINI, *Ind. & Eng. Chem.* **39** (1947) pp. 1072-81.

Since 1934 the Bureau of Standards has made use of the fractionating process of adsorption in its work on the separation and purification of hydrocarbons. The paper describes the assembly and testing of a large laboratory adsorption column having a stainless steel fractionating section ¾-inch in inside diameter and 52.4 feet long, and containing silica gel (largely 200 to 325 mesh size) as the adsorbent. The operating procedure including regeneration of adsorbent in place, is described. Results are given on the separation obtained by the use of this column on a synthetic mixture of *n*-dodecane, triethylbenzenes, and 1-methylnaphthalene and on a sample of the kerosene fraction of petroleum. Data are also given on the fractionation obtained in a glass adsorption column 0.4 inch diameter and 26 feet length, with the same silica gel as the adsorbent, and on binary mixtures of hydrocarbons selected to disclose differences in adsorbability arising from differences in molecular size and structure.

In the order of decreasing adsorbability, several structural components can be listed as (a) dinuclear or polynuclear aromatics, (b) phenyl, and (c) cycloparaffin and paraffin, with *a* and *b* as a class very much more strongly adsorbed than *c*. That is to say, the addition of a phenyl group to a paraffin or cycloparaffin results in a molecule having an adsorbability in the class of *a* and *b*. Increasing the number of carbon atoms in an *n*-alkyl group decreases the adsorbability. Cyclopentane is more strongly adsorbed than cyclohexane. With the same number of carbon atoms, a normal paraffin is more strongly adsorbed than an isoparaffin. *n*-Hexane is more strongly adsorbed than cyclohexane. Amongst the aromatics, ortho-substituted compounds are more strongly adsorbed than the para-substituted. A bibliography of 14 references is included.

Semimicroanalysis of Light Hydrocarbon Mixtures by Multiisothermal Distillation. L. S. ECHOLS, JR. AND EDWARD GELUS, *Ind. & Eng. Chem., Analytical Ed.* **19** (1947) pp. 668-75.

The authors describe a method for the analysis of light hydrocarbon mixtures containing hydrogen, nitrogen, and the olefinic and paraffinic hydrocarbons through the butanes. The method is based on a controlled vaporization of the sample and includes two complementary techniques referred to as isothermal distillation and multiisothermal distillation. The first is designed specifically for the analysis of mixtures of propane, isobutane, *n*-butane, and isopentane. It requires a gaseous sample of 2 ml. at normal temperature and pressure. The second method embraces the remaining components and requires a gas sample of about 50 ml. at normal temperature and pressure. An over-all accuracy of about 1 percent can be obtained. In considering methods of analysis, one requirement was that the time required should not exceed 3 to 4 hours, and another that the equipment be simple in design and easy to operate. Procedure and apparatus are described in considerable detail as well as the calculation methods that can be applied to the data.

Improved Dithizine Method for Determination of Lead. L. J. SNYDER, *Ind. & Eng. Chem., Analytical Ed.* **19** (1947) pp. 684-7.

The colorimetric dithizine method for the determination of lead was studied, and a new procedure developed based on extraction of the lead from an aqueous solution at pH of 11.5. A saving in time and an improvement in the convenience and flexibility of the method are realized as a result of extending the working range of the method to analyze samples from 1 to 450 micrograms in various cell sizes and with a standard dithizone solution. The new method eliminates the need for titrimetric extraction to estimate the sample size within narrow limits and for selection of the proper cell size and standard dithizone solution prior to the final color development. The procedure is described in detail including preparation of all of the reagents. Results of typical analyses are tabulated.

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REFINING

U.S.P. 2,423,802. Process of Separating Alpha Methyl Styrene from a Mixture Containing Cumene. O. C. Slotterbeck and C. E. Morrell to Standard Oil Development Co.

Alpha methyl styrene is separated from a mixture containing cumene by aralkylating cresol by reaction with the alpha methyl styrene contained in the mixture. The reaction product is separated from unreacted cumene and then heated to a temperature sufficiently high to evolve alpha methyl styrene vapors, e.g. to a temperature of 150-200°C.

U.S.P. 2,424,158. Process of Refining a Petroleum Oil Containing Naphthenic Acids. M. C. Fuqua and J. B. Lovell to Standard Oil Development Co.

Petroleum oil containing naphthenic acids is contacted with a solution consisting of a low mol. w. water-soluble oxygen containing organic solvent, such as a lower aliphatic alcohol, having dissolved therein an organic water-soluble and alcohol-soluble amine, such as an alkylol amine, that reacts with the naphthenic acids to form naphthenates. These naphthenates are separated from the oil together with unreacted amine dissolved in the solvent which remains undissolved in the oil. The oil, e.g. crude petroleum oil, is thus left free of naphthenic acids and is made substantially non-corrosive during storage, distillation and other refining treatments.

U.S.P. 2,426,110. Distillation of Crude Petroleum. W. E. McCorquodale and L. G. Magill to Sun Oil Company.

Crude petroleum is preheated and then subjected to reduced pressure. It is flash distilled to separate the crude into only two products, namely a vaporized low boiling product and a reduced crude. The low boiling product is removed from the distillation zone in vapor phase and cooled so that condensible constituents are condensed, whereafter it is introduced directly into a fractional distillation zone. The reduced crude is heated to partial vaporization and then introduced into the same fractional distillation zone at a point substanially below that of introduction of the low boiling product. The condensation of the low boiling product vapors before introduction of this product into the fractional distillation zone makes possible a substanially greater throughput in this zone.

U.S.P. 2,426,558. Process for Removal of Hydrogen Fluoride from Nonaqueous Fluids and Porous Body for Use in Such Process. K. E. Long and H. W. Cromer to Harshaw Chemical Company.

HF is removed from fluids containing it by absorbing the HF in pellets of NaF at a temperature of 85-200° C. These pellets are mechanically strong bodies of a volume not less than 0.025 cc. and an apparent density of 1.3-1.5 grams per cubic centimeter.

U.S.P. 2,426,624. Extraction of Quinonoid Hydrocarbons from Benzenoid Hydrocarbons by Means of Anhydrous Hydrogen Fluoride. A. P. Lien to Standard Oil Company of Indiana.

A mixture of a quinonoid hydrocarbon and a benzenoid hydrocarbon is extracted with liquid, anhydrous HF. The quinonoid hydrocarbon is obtained in the extract. Anthracene can be separated by this method from phenanthrene, or an aromatic hydrocarbon fraction produced by cracking a petroleum oil can be treated in this manner.

U.S.P. 2,426,705. Recovery of Isoprene by Fractionation and Extractive Distillation. J. A. Patterson and H. W. Scheeline to Standard Oil Development Company.

Isoprene of high purity is separated from a hydrocarbon rich in C_5 hydrocarbons, both mono-olefiins and diolefins, including isoprene, 2-methylbutene -2, cyclopentadiene, straight chain C_5 dienes and cyclopentene, such as obtained by cracking a petroleum oil. For this purpose, the hydrocarbon fraction is subjected to at least two distillation stages each conducted in a separate fractionating tower. One of these stages is effected in the absence of a volatile modifier wherein reflux ratio and number of contact stages are interadjusted to effect separation between a distillate fraction containing isoprene, 2-methylbutene-1, pentene-1, 2-methyl butene-2 and substantially free of cyclopentene, and a second fraction containing cyclopentadiene straight chain C_5 dienes and cyclopentene. The other distillation stage uses the distillation fraction containing isoprene in the presence of acetone or furfural. This volatility modifying solvent is introduced substantially above the point of hydrocarbon feed supply in an amount sufficient to maintain a large proportion of at least 2 volumes of this solvent per volume of hydrocarbon in the liquid phase present above the feed plate in the distillation zone. The hydrocarbon reflux ratio, solvent to hydrocarbon ratio and number of contact stages are interadjusted to effect substanially complete separation of isoprne from the C_5 olefins in the isoprene-containing fraction. The solvent is recycled to the distillation zone after separation from the isoprene.

U.S.P. 2,426,706. Segregation of Olefinic Hydrocarbons by Extractive Distillation. J. A. Patterson to Standard Oil Development Company.

Olefinic hydrocarbon (e.g. piperlyene) is separated from a mixture contaning relatively more saturated hydrocarbons of the same number of C atoms (e.g. a mixture containing piperlyene, olefins and paraffins of 5 C atoms) and also hydrocarbons with a greater number of C atoms, i.e. from mixtures such as obtained in the heat treatment of petroleum fractions. The hydrocarbon mixture is passed as feed to a distillation tower to the upper portion of which a normally liquid polar organic solvent capable of forming azeotropes with the relatively saturated hydrocarbons of the mixture and having a volatility between those of the lightest and heaviest hydrocarbons in the mixture, such as acetone or furfural, is supplied. The solvent is suppplied in substantial excess of the amount to be distilled overhead and at a point substanially above the feed level. A zone of extractive distillation is thus provided between the feed supply and the solvent supply. Heat is supplied to the bottom of the distillation tower to exclude the olefinic hydrocarbon to be recovered and the solvent from the tower bottoms. The tower bottoms comprising essentially the hydrocarbons with a relatively greater number of C atoms are withdrawn. A distillate comprising azeotropes of the solvent and the relatively more saturated hydrocarbons is withdrawn from the top of the column. A side stream is withdrawn from the tower at a point substantially below the feed inlet. This side stream comprises the solvent and the major portion of the olefinic hydrocarbon to be recovered in a state of greatly increased purity.

U.S.P. 2,426,709. Stabilization of Motor Fuels. T. C. Roddy, Jr., to The Texas Company.

A motor fuel comprising gasoline and normally tending to deteriorate on storage is stabilized by the addition of small amounts of an unsaturated fatty acid and a phenol. A mixture of oleic acid and cresylic acid can, for example, be used as the additive.

U.S.P. 2,426,766. Stabilization of Organic Substances. F. B. Downing and C. J. Pedersen to E. I. du Pont de Nemours & Company.

The catalytic effect of metal compounds on olefinic distillates, e.g. on olefinic motor fuel gasoline, is suppressed by the addition of a relatively small amount of 2-hydroxy-1-naphthylidene-ortho-aminophenol.

U.S.P. 2,426,821. Azeotropic Distillation of Five Carbon Diolefins in the Presence of Methyl Formate. T. W. Evans, R. C. Morris, and E. C. Shokal to Shell Development Company.

A mixture of acyclic diolefins and mono-olefins with 5 C atoms per mol., such as obtained in the cracking of a straight-run gasoline fraction, is mixed with methylformate in a quantity at least sufficient to form minimum-boiling azeotropic mixtures with all of the hydrocarbons. The mixture thus formed is fractionally distilled. An initial fraction

comprising an azeotropic mixture with predominating hydrocarbon content in mono-olefins and a higher boiling fraction comprising an azeotropic mixture with predominating hydrocarbon content in diolefins are obtained. The hydrocarbons from each of these azeotropic mixtures are separated. Isoprene, piperylene, etc., can thus be isolated.

U.S.P. 2,427,173. Fuel. L. L. Withrow to General Motors Corporation.

The fuel consists of a leaded gasoline containing a small amount (e.g. 1-3 cc. per gallon) of trimethyl phosphate or trimethyl phosphite, or both. The fuel is particularly suitable for high-compression, spark-ignition engines. The addition of the phosphorus compounds reduces or suppresses autoignition.

U.S.P. 2,427,212. Removal of Peroxides from Hydrocarbon Oils. L. M. Henderson, D. C. Bond, and M. Savoy to The Pure Oil Company.

Hydrocarbon oils, particularly cracked oils, deteriorated during storage by the formation of peroxides, are contacted with an alkali solution containing a phenolic substance which is capable of being oxidized to the quinone structure to reduce the peroxide content of the oil. A high-boiling fraction of hard wood tar, e.g. a fraction boiling between 240-300° C., butyl pyrogallol, or tanic acid can, for example, be used. The spent alkali solution can be regenerated by contact with mercaptan-containing hydrocarbon oil.

U.S.P. 2,427,326. Treatment of Mineral Oil Emulsions. P. M. Goodloe and T. T. Noland to Socony-Vacuum Oil Company, Inc.

Mineral oil emulsions of the water-in-oil type are separated into their constituent parts by subjecting the emulsion to the action of an emulsion breaker which includes water, urea and a colloidally active organic substance tending to stabilize emulsions of the oil-in-water type. The emulsion breaker can, for example, be a Na, K, or (NH_4) salt of a soap forming fatty acid, a naphthenic acid, or a petroleum sulfonic acid. Urea lowers the temperature at which active emulsion-breaking agents separate from acqueous "solutions" thereof.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,425,584. Conditioning Sulphuric Acid Sludge. E. F. Wadley and J. T. Horeczy to Standard Oil Development Company.

Concentrated sulfuric acid which has been employed as alkylation catalyst and contains substantial amounts of carbonaceous materials is subjected to a temperature of 100-120° F. for not less than 5 hours immediately after it is withdrawn from the alkylation process. This treatment prevents the otherwise occurring solidification of the spent catalyst during storage. The contaminated sulfuric acid catalyst can subsequently be stored for an indefinite period of time prior to being regenerated.

U.S.P. 2,425,745. Recovery of Hydrogen Fluoride from Gases. A. B. Leonard and G. R. Hettick to Phillips Petroleum Company.

Hydrocarbons are converted and in particular low-boiling isoparaffins, such as isobutane, are alkylated in the presence of a HF catalyst in a reaction zone. Effluent from this zone is passed to a separating means to separate a hydrocarbon phase from a liquid HF phase. The hydrocarbon phase is subjected to distillation to separate a low-boiling fraction comprising HF and low-boiling hydrocarbons from a high-boiling hydrocarbon fraction substanially free from HF. The low-boiling fraction is cooled and condensed and passed to an accumulator. Resulting condensate is passed to the reaction zone. A gaseous fraction comprising low-boiling hydrocarbons and HF is removed from the accumulator and passed to an absorber where it is contacted with an absorption liquid comprising an olefin-containing hydrocarbon material. Unabsorbed gases are discharged. The resulting rich absorption liquid containing HF and alkyl fluoride is passed to the separating means.

U.S.P. 2,425,752. Separation of Hydrogen Fluoride from Water and Organic Contaminants by Distillation and Decantation. G. E. McKenna and G. R. Hettick to Phillips Petroleum Company.

A used HF catalyst, as employed in the conversion of hydrocarbons, and which contains water and high-boiling organic contaminants is passed as a liquid to a distillation zone. A low-boiling fraction comprising purified HF and a high-boiling fraction comprising water, organic compounds and HF in an amount in excess of that which forms an aqueous azeotropic mixture are recovered from the distillation zone. The organic compounds are separated from the high-boiling fraction. A residual aqueous HF is subjected to a flash distillation to decrease the HF content thereof. The unvaporized residue from the flashing operation is discharged. Vapors from the flashing are mixed with the low-boiling fraction. The resulting mixture is cooled and condensed. A further portion of the condensate is passed to the distillation zone as a reflux liquid. A further portion of the condensate is recovered as a purified HF product.

U.S.P. 2,425,849. Powdered Catalyst Regeneration and Recovery. V. Voorhees to Standard Oil Company (Indiana).

Spent powdered catalyst contaminated with carbonaceous deposits is suspended in an upwardly flowing oxygen-containing gas stream in a first regeneration zone wherein the amount of oxygen gas is sufficient to cause only partial combustion of the deposits and to keep the temperature of the catalyst within safe limits. A gas substanially free from uncombined oxygen but containing substantial amounts of CO is produced in this zone. This gas is separated from the bulk of the catalyst, and the latter is introduced into a second regeneration zone where the catalyst is suspended in an upwardly flowing stream of oxygen-containing gas. This gas is introduced into the second zone at relatively low temperature in an amount to provide a substantial excess of uncombined oxygen in the regeneration gases leaving the zone. Regenerated catalyst is separated from these regeneration gases. In a third zone CO in gases from the first zone is burnt with uncombined oxygen in the regeneration gases frmo the second zone.

U.S.P. 2,426,087. Conversion of Hydrosulfides to Neutral Sulfur Substances. L. C. Fetterly to Shell Development Company.

Spent aqueous alkaline solutions containing hydrosulfides or mercaptans, such as obtained by extraction of sour hydrocarbons, are contacted with an oxygen-containing oxidizing agent in the presence of a small amount of a nitrobenzene oxidation catalyst containing attached to the benezene nucleus two polar groups consisting of either amino or hydroxy groups, or mixtures thereof. Free sulfur and organic disulfides are produced by this oxidation, while the spent alkaline solution is regenerated. Picramic acid can, for example, be used as the oxidation catalyst in an amount of 0.1-5 percent by weight of the solution. Air can be used as the oxidizing agent at about 70° F.

U.S.P. 2,426,088. Method for Eliminating Foaming in the Recovery of Sulfuric Acid from an Olefin Recovery Operation. B. M. Filbert to Standard Oil Development Company.

An extract resulting from the contact of H_2SO_4 with low mol. wt. olefins, e.g. a C_4 hydrocarbon feed containing olefins, is mixed with water-soluble green sulfonic acids in an amount sufficient to eliminate foaming of the extract under reduced pressure. The extract is then heated under reduced pressure to recover olefins therefrom. The amount of the added sulfonic acids is preferably such that a concentration of about 0.025 percent by volume of these acids is obtained in the extract.

U.S.P. 2,426,483. Reactivation of Sulfide Catalysts. H. G. Boucher and T. F. Leeds to Shell Development Company.

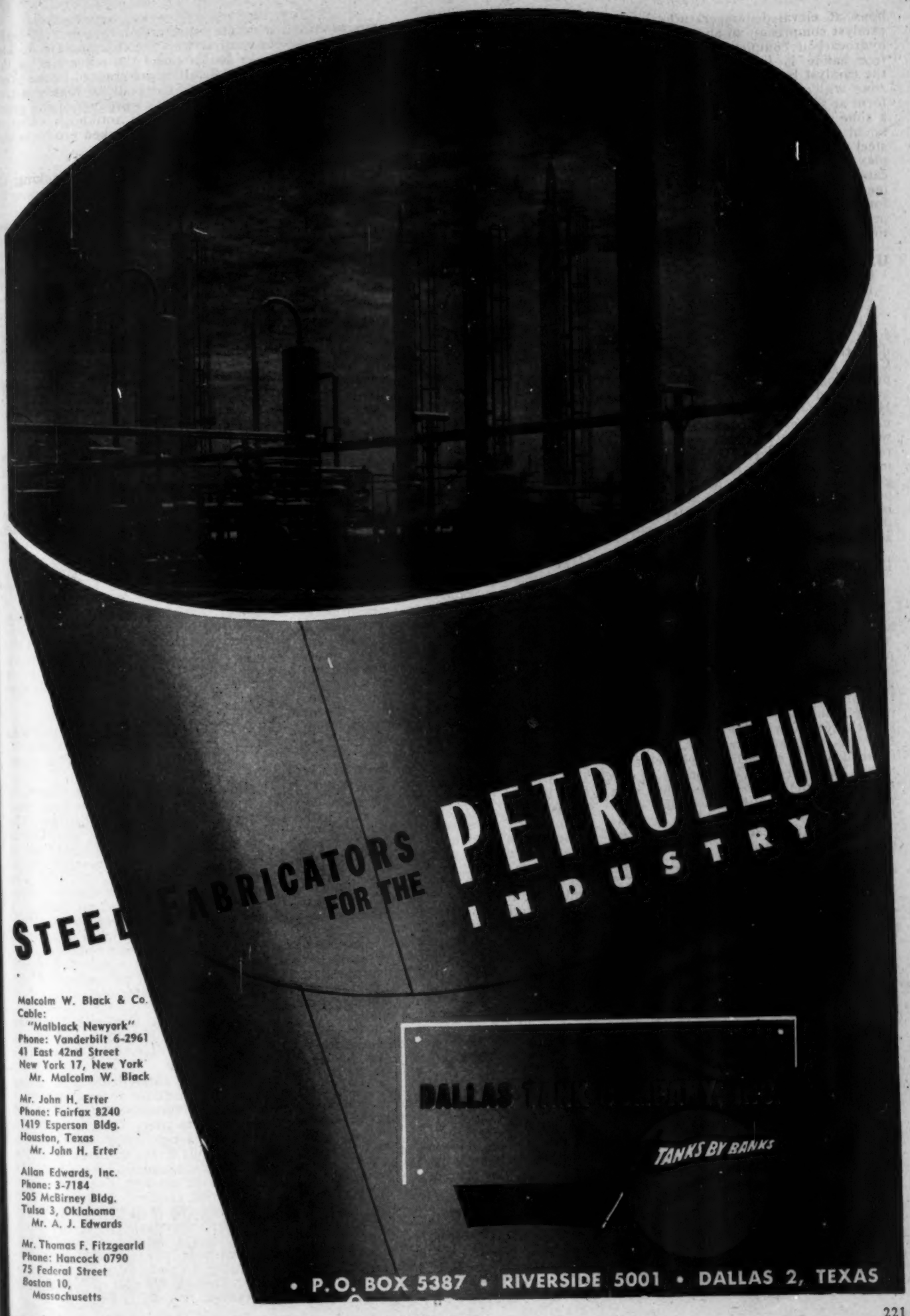
Spent catalysts comprising the sulfides of W, Mo, Ni, W-Ni, W-Co, W-Fe, Mo-Ni, Mo-Co, or Mo-Fe are treated for several hours with a stream of air at a temperature of 350-550° F., but below that at which active exorthermic reaction of the carbonaceous deposits or the sulfur sets in. The cataltic activity of the catalyst is restored by this treatment without appreciable oxidation of carbonaceous deposits. It has been found that the deactivation of this type of catalyst is not primarily due to deposition of carbonaceous products but to some other unknown cause.

U.S.P. 2,426,678. Revivification of Phosphate Catalysts. H. Greenberg to U. S. Industrial Chemicals Inc.

Spent solid dehydration phosphate catalyst, such as employed in the production of 1,3- butadiene from 1,3-butylene glycol, is revivified by passing over the catalyst a volatilized ester of phosphoric acid which is stable at its volatilization temperature, and maintaining the catalyst at a temperature at which the ester is decomposed to deposit free phosphoric acid. The treating temperatures can be in the range of 220-400° C. Triethyl phosphate can, for example, be used as the treating ester.

U.S.P. 2,426,693. Reducing Corrosive Action of Friedel-Crafts Type Catalyst. W. Kiersted, Jr., to The Texas Company.

Corrosion of ferrous metals parts in the reaction zone of the catalytic conversion (e.g. isomerization) of hydrocar-



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bons at elevated temperatures with a catalyst comprising an aluminum halide-hydrocarbon complex liquid containing free halide is inhibited by contacting the catalyst liquid in a separate treating zone with metallic Fe in finely-divided form at an elevated temperature and for a time sufficient to render the catalyst liquid relatively non-corrosive to boiler steel at 210° F. The non-corrosive complex thus obtained is then passed as the catalyst to the reaction zone. The treatment of the catalyst liquid with Fe can, for example, be carried out at a temperature of 150-250° F. for a period of time of 1-48 hours.

U.S.P. 2,426,832. Removal of Catalyst from Reaction Product. J. W. Latchum, Jr., to Phillips Petroleum Company.

The vaporous reaction zone effluents from the vapor phase conversion of hydrocarbons in the presence of a Friedel-Crafts type metal halide catalyst and promoting hydrogen halide are scrubbed at elevated temperature with liquid conc. H_2SO_4 under conditions effecting removal of the metal halide therefrom, with consequent formation of the corresponding hydrogen halide while avoiding any substantial removal of hydrogen halide. Hydrogen halide originally present and formed during the scrubbing is separated from the thus-treated effluents and then returned to the reaction zone as catalyst promoter.

U.S.P. 2,426,841. Recovery of Hydrogen Fluoride. C. C. Peavy and J. Happel to Socony-Vacuum Oil Company, Inc.

The reaction mixture obtained in the alkylation of isoparaffins with olefins by means of HF is settled to yield an acid phase and a hydrocarbon phase and light gaseous hydrocarbons containing gaseous HF vented from the hydrocarbon phase. The light gaseous mixture thus obtained is scrubbed with H_2SO_4 to selectively absorb HF. The enriched H_2SO_4 is stripped to recover HF therefrom. The HF so recovered is returned to the reaction zone. A portion of the HF from the acid phase containing water is reacted with fluosulfonic acid. A mixture of HF and H_2SO_4 is withdrawn from this reaction and introduced into the stripping zone.

CRACKING AND REFORMING

U.S.P. 2,425,555. Catalytic Conversion of Hydrocarbons. E. T. Nelson to Universal Oil Products Company.

Subdivided solid cracking catalyst of progressively increasing activity is maintained at cracking temperature in a series of reaction zones. Hydrocarbons are contacted with the catalyst in each of the zones. The vapors from each zone are independently fractionated to separate gasoline fractions from heavier fractions. A virgin charging oil heavier than gasoline is supplied to the first zone. Gasoline fractions separated from the vapors from a preceding zone are supplied to the last zone. Fractions heavier than gasoline separated from the vapors from the first zone are supplied to an intermediate zone. Contaminated catalyst particles from the first zone are removed and regenerated. The catalyst thus regenerated is introduced to the last zone. Catalyst particles from the last zone are transferred to the intermediate zone and from the latter to the first zone. The motor gasoline produced is suitable as base stock for aviation gasoline. By the treatment in the last zone the olefin content of gasoline fractions derived from preceding zones is reduced and the lead susceptibility of the gasoline is increased.

U.S.P. 2,425,807. Contacting Solids and Gaseous Fluids. C. E. Jahnig to Standard Oil Development Company.

A subdivided solid catalyst and a gaseous fluid are contacted by introducing them into a contacting or reaction zone where the solid particles are maintained as a fluidized dense liquid-simulating mixture. The mixture is withdrawn from the lower portion of the contacting zone and passed to the bottom of a stripping zone. Stripping gas is introduced into the lower portion of the stripping zone at a velocity selected to maintain the particles in a dense fluidized liquid-simulating condition during stripping. The stripped particles are removed from the bottom portion of the stripping zone in dense fluidized condition while stripping gas and stripped-out constituents are removed from the upper portion of the stripping zone. This method can, for example, be used in the catalytic cracking of hydrocarbons. A thorough stripping of contaminated catalyst is obtained by this process.

U.S.P. 2,425,960. Process for Hydrocarbon Conversion. W. A. Schulze to Phillips Petroleum Company.

A stream of vaporized gas oil is introduced at a temperature of 850-1100° F. and at a low superatmospheric pressure into a closed zone containing a bauxite catalyst. The oil is cracked. Unconverted gas oil and relatively heavy hydrocarbon material is removed from the effluent of the cracking step, and the unconverted gas oil is recycled to the cracking step. The remaining effluent is fractionated into a gasoline fraction and a lighter fraction containing free hydrogen and isoparaffins of 5-6 C atoms. A gas rich in free hydrogen is added to the gasoline fraction. The mixture formed is passed at a temperature of 900-1100° F. and slightly superatmospheric pressure into a second closed zone containing a bauxite catalyst, wherein the gasoline is reformed. The above named lighter fraction is introduced into the effluent from the second zone. From the combined fluid thus formed components heavier than gasoline are separated. The remaining combined fluid is fractionated for separation of the isoparaffins together with a gasoline of improved antiknock properties and of a gaseous fraction containing free hydrogen. A gas boiling higher than methane is separated from the gaseous fraction to obtain a gas rich in free hydrogen. At least a portion of this hydrogen-rich gas is recycled to the second zone.

U.S.P. 2,426,233. Production of Aviation Base Fuel. R. H. Newton to Houdry Process Corporation.

Hydrocarbon charging stock, particularly such heavier than gasoline, is cracked in the presence of a body of highly active cracking catalyst. A light normally liquid distillate with an end point in the range of 180-260° F. and a heavier distillate with a boiling range from the end point of the light distillate to a temperature in the range of 325-475° F. are separated from the cracked products. A portion only of the heavier distillate is returned to the first body of catalyst with the charging stock. The light distillate and the remainder of the heavier distillate are cracked in the presence of a second body of highly active cracking catalyst. A product of the gasoline type with high antiknock value is separated from the cracked products obtained.

U.S.P. 2,426,273. Catalytic Cracking of Hydrocarbons. W. W. Johnstone to Universal Oil Products Company.

A hydrocarbon charge, particularly high boiling hydrocarbons comprising a gas oil, is subjected to the action of a catalyst comprising HF and Al at a cracking temperature (e.g. 150-400° F.) and under a pressure sufficient to maintain the HF and hydrocarbons substantially in the liquid phase. The metallic Al serves as a promoter for the HF catalyst.

U.S.P. 2,426,495. Method of Producing Gasoline of High Antiknocking Characteristics. F. C. Fahnestock to Socony-Vacuum Oil Company.

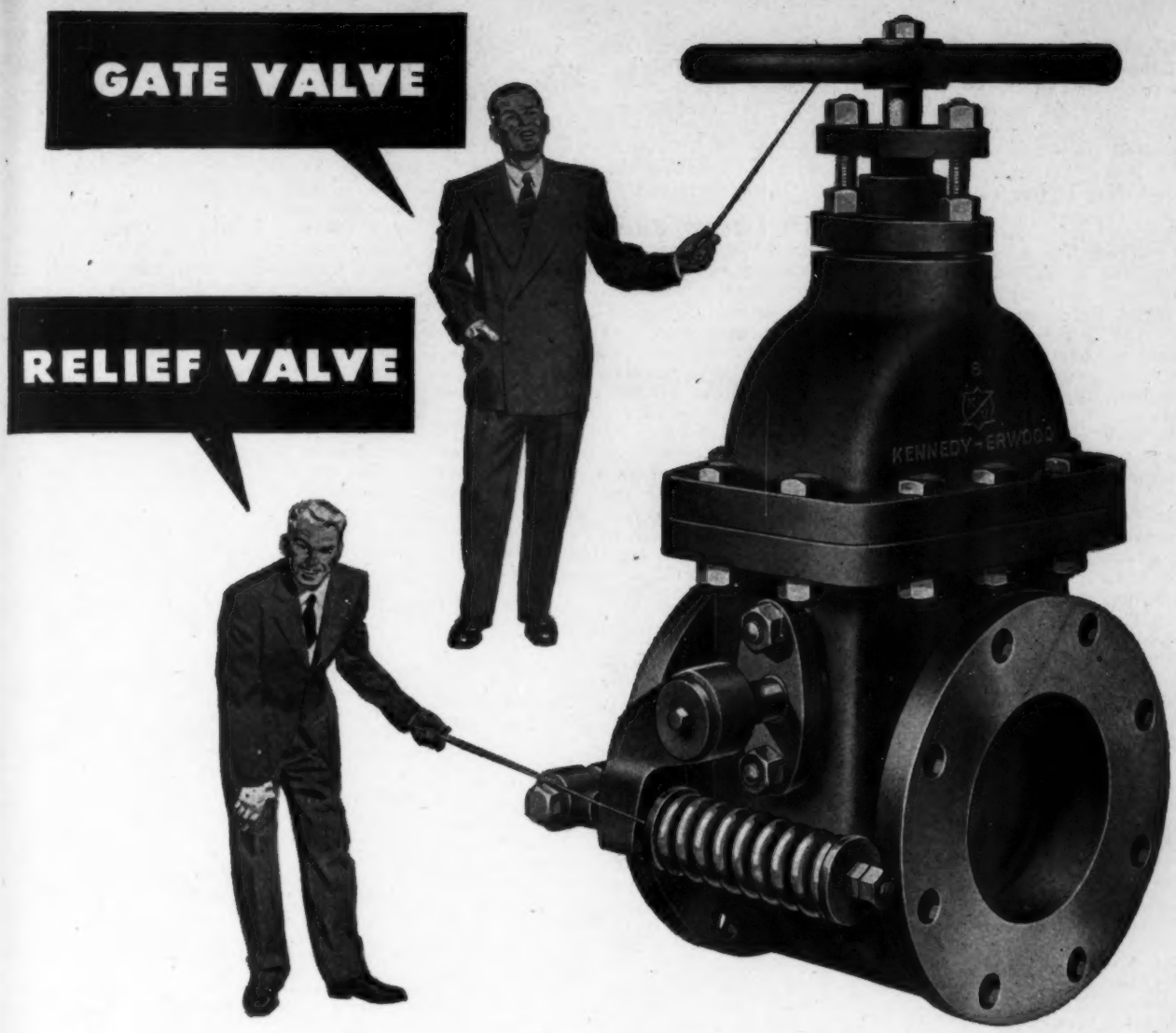
Petroleum gas oil is cracked to gasoline, preferably in the presence of a solid adsorptive catalyst. Material of gasoline boiling range is separated from the cracking effluent and subjected to solvent refining in the presence of an extractive agent, such as SO_2, under such conditions as to separate from the gasoline only the most highly paraffinic, substantially straight-chain compound portion thereof. This paraffinic portion is rejected. The remainder is freed of extractive agent and again cracked in the presence of solid adsorptive catalytic material. A gasoline of desired boiling range is selected from the products of the second cracking. A material of high antiknock value is thus obtained.

U.S.P. 2,426,848. Cracking Hydrocarbons in the Presence of Granular Coke. M. H. Tuttle to Max B. Miller & Company, Inc.

From a petroleum stock fractions which volatilize below the coking temperature of the stock are distilled. The liquid residue of the stock is coked at the top of a deep incandescent bed of loose granular coke maintained by burning coke at the bottom of the bed. The vaporized fractions of stock are introduced into the incandescent bed at a point spaced below its top so that they are caused to flow through a substantial portion of the bed. The vaporized hydrocarbons are thus cracked continuously to yield a high percentage of aromatics and unsaturates.

U.S.P. 2,426,869. Catalytic Cracking Process. J. P. Hamilton and A. C. Rubey, Jr., to Standard Oil Development Company.

A system for catalytically converting hydrocarbons includes at least two units each of which comprises a reaction and a regeneration zone. One unit has a higher catalyst equilibrium activity than the other unit. Fresh catalyst is added to the catalyst circulating in each of the units, and used catalyst is removed from the circulating catalyst of each unit. The catalyst removed from the unit of lower catalyst equilibrium activity is discarded, while at least a portion of the catalyst withdrawn from the unit of higher catalyst activity is added to the catalyst circulating through the unit of lower catalyst activity.



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U.S.P. 2,426,903. Conversion of Hydrocarbon Oils. W. J. Sweeney to Standard Oil Development Company.

A higher boiling oil, such as gas oil reduced crude, is cracked under conditions controlled to produce an olefinic gasoline fraction. This fraction is separated into a higher boiling naphtha fraction and a lower boiling naphtha fraction. The higher boiling naphtha fraction is further cracked. The recracked naphtha is separated into a light naphtha fraction and a heavy naphtha fraction. The recracked light fraction is combined with the lower boiling naphtha fraction from the first cracking. Olefinic constituents are removed from this combined fraction. Thereafter the thus treated light naptha fraction is combined with the recracked heavy naphtha fraction. A gasoline suitable for aviation fuel is obtained.

U.S.P. 2,427,009. Catalytic Cracking of Hydrocarbons in the Presence of Hydrogen Fluoride and Boron Fluoride. A. P. Lien, B. L. Evering, and B. H. Shoemaker to Standard Oil Company (Indiana).

A high-boiling hydrocarbon stock containing aromatics is dispersed upwardly through a liquid column of catalyst consisting essentially of liquid HF and about 1-40 percent of BF_3 based on the weight of the HF, at a rate such that the contact time is sufficient to effect substantial cracking. This rate is preferably selected from space velocities of 0.2-4 volumes of charging stock per hour per volume of liquid catalyst in the column. A temperature of 100-400° F. and a pressure sufficient to maintain liquid phase reaction conditions are maintained within the reaction zone. The reaction mixture obtained is separated into a light upper layer and a heavier lower layer. Catalyst is recovered from the upper layer which is then fractionated. Catalyst material and aromatic hydrocarbons are recovered from the lower layer. Both portions of recovered catalyst are returned to the reaction zone.

ISOMERIZATION

U.S.P. 2,425,858. Process for Isomerizing Tertiary Olefins. L. K. Beach to Standard Oil Development Company.

A tertiary olefin with at least 5 C atoms is contacted with a phenol in the presence of an alkylating catalyst at a temperature of 0-100° C. The alkylated phenol formed is separated from unreacted tert. olefin and heated to a temperature not substantially above the b.p. of the alkylated phenol at a regeneration pressure to obtain overhead a mixture of the isomers of the tert. olefin. These isomers are separated individually. One of them is retained as product while the other is recycled to the tert. olefin phenol mixture.

ALKYLATION

U.S.P. 2,425,572. Alkylation. O. C. Slotterbeck to Standard Oil Development Company.

Isoparaffins are alkylated with olefins or iso-olefins in the presence of conc. H_2SO_4 as the catalyst. A minor amount (e.g. 1-10 percent by weight) of chlorosulfonic acid as a promoter is maintained in the catalyst. The yields of the alkylation product are materially increased by the presence of this promoter, while the amount of unsaturated byproduct is reduced. The reaction can be carried out more selectively over a wider range of temperatures than in the absence of the promoter. Treating temperatures of 0-30° C. are preferred.

U.S.P. 2,425,839. Catalytic Alkylation of Aromatic Hydrocarbons. W. A. Schulze and W. N. Axe to Phillips Petroleum Company.

An aromatic hydrocarbon, e.g. benzene, is reacted with an unsaturated aliphatic hydrocarbon, e.g. propylene, in the presence of a catalyst comprising a liquid addition product of BF_3 and an aliphatic monohydric alcohol corresponding in number of C atoms and in molecular structure to the unsaturated aliphatic hydrocarbon, such as a propyl alcohol, at a temperature not exceeding about 130° F. The new alkylation catalysts do not require the presence of a promoter and are reactive at moderate temperatures and pressures. They form relatively stable liquids.

U.S.P. 2,426,559. Alkylation of Isoparaffins by Means of Normal Olefins in the Presence of Hydrofluoric Acid. M. P. Matuszak to Phillips Petroleum Company.

Isobutane is alkylated with butenes, comprising n-butenes, in the presence of a conc. HF catalyst. The water content of the catalyst (expressed in wt. percent of HF) is maintained within a range the lower limit of which is determined by 4 times the mol fraction of butene-1 of the total of the butenes plus 2 times the mol fraction of butene-2 of the total of the butenes, and the upper limit of which range is determined by 6 times the mol fraction of butene-1 plus 4 times the mol fraction of butene-2. The alkylate thus produced is said to be so superior in octane rating that the disadvantages attendant upon the presence of water in the HF catalyst (increased corrosion of equipment, decreased alkylate yield, increased formation of organic fluorine compounds) are more than compensated for.

U.S.P. 2,426,665. Alkylation of Aromatic Hydrocarbons. H. S. Bloch to Universal Oil Products Company.

An aromatic hydrocarbon is reacted with an olefinic hydrocarbon at a temperature below 150° C. in the presence of an alkylation catalyst comprising a mixture of a major mol proportion of an aluminum halide and a minor proportion of a zinc halide. The halides are so proportioned that their mixture is in a molten condition at the alkylation temperature, e.g. at 125° C. 2 mols of $AlCl_3$ can, for example, be mixed with 1 mol of $ZnCl_2$. The catalyst described is very efficient and is altered only slightly in the course of reaction.

U.S.P. 2,426,611. Alkylation Process. T. B. Hudson, I. L. Wolk, and J. D. Upham to Phillips Petroleum Company.

An alkylatable hydrocarbon, e.g. isobutane, is alkylated with an olefin by flowing a stream of the saturated hydrocarbon through a series of contactors and settlers, introducing olefin into each of the contactors maintained at alkylation conditions, and also introducing catalyst into each of them from an extraneous source as well as into each of them except the last from succeeding settlers. A large excess of the alkylatable hydrocarbon over the olefin is maintained throughout the series of contactors and settlers. A mixture of hydrocarbons and catalyst is passed from each contactor to the first succeeding settler, where a hydrocarbon phase is separated from a catalyst phase. The hydrocarbon phase from each except the last settler is passed to the first succeeding contactor, while catalyst phase from each settler except the first is passed to the second preceding contactor to effect countercurrent flow of catalyst and hydrocarbons in the system. Hydrocarbons are withdrawn from the last settler, while catalyst is withdrawn from the first settler. The activity, quantity and temperature of the catalyst introduced into each contactor from the extraneous source are separately controlled so as to provide an increasing amount of catalyst in the direction of flow of catalyst and to remove a substantial amount of the heat of reaction. Concentrated H_2SO_4 or HF can be used as the catalyst.

U.S.P. 2,427,293. Alkylation Process. M. P. Matuszak to Phillips Petroleum Company.

A low-boiling isoparaffin, such as isobutane, is reacted with a low-boiling tertiary base olefin, such as isobutene, under alkylating conditions in the presence of conc. HF. A fraction comprising unreacted isoparaffin and a minor amount of organic fluorine compounds is separated from the reaction effluents. This fraction is reacted with a low-boiling nontertiary-base olefin, such as n-butene, under alkylation conditions in the presence of conc. H_2SO_4. Higher boiling paraffin hydrocarbons produced in both these reactions are recovered from the effluent of each reaction.

POLYMERIZATION AND CONVERSION

U.S.P. 2,425,493. Process for Catalytic Polymerization of Olefins. V. Stapleton to The Texas Co.

Unsaturated hydrocarbons comprising olefins with a smaller and olefins with a higher number of C atoms, e. g. C_4 and lighter olefins, are passed into contact with a polymerizing catalyst maintained in solid particle form within a reaction zone at a predetermined superatmospheric pressure and at a suitable elevated temperature. The resulting polymerized olefins are removed from the reaction zone. The proportion of olefin of smaller number of C atoms passed to the reaction zone is periodically decreased for a short interval of time without reduction in the predetermined pressure. This periodical decrease of the flow of the lighter olefin component eliminates darkening of the product stream of the continuous polymerization process and increases the yield of polymer gasoline while the activity of the catalyst is kept constant for a prolonged period of time extending over many months. The process can be carried out at a temperature of 300-600° F. and a pressure of 200-2000 psi.

U.S.P. 2,425,559. Catalytic Conversion of Alkyl Aromatic Hydrocarbons. H. J. Passino and H. G. McGrath to The M. W. Kellogg Company.

From a mixture of poly-alkylated aromatic hydrocarbons a portion is sepa-

rated in which the ratio of poly-alkylated aromatic hydrocarbons with the alkyl groups attached to adjacent C atoms in the benzene ring to those with alkyl groups attached to non-adjacent C atoms is greater than in the original mixture. This separated portion is isomerized with a HF catalyst to convert the poly-alkylated aromatic hydrocarbons to isomers with no alkyl groups attached to adjacent C atoms in the benzene ring. A mixture of xylenes can, for example, be treated in the described manner. A cracking treatment can be combined with the isomerization treatment by operating at a temperature above 250° F. to isomeriz poly-alkylated aromatic hydrocarbons and to effect cracking in the alkyl groups containing more than two C atoms. The motor fuel value of the mixture is improved by the process. The mixture of poly-alkylated aromatic hydrocarbons used as the starting material in the process can be produced from a feed stock containing non-aromatic hydrocarbons with at least 8 C atoms by aromatization in the presence of a dehydrogenating catalyst.

U.S.P. 2,425,638. Polymerization of Ethylene. M. D. Peterson to E. I. du Pont de Nemours & Company.

Ethylene is continuously homopolymerized at a pressure above 1000 atmospheres by passing the ethylene together with a dialkyl oxide of the formula ROOR′ in which R and R′ are simple unsubstituted alkyl groups containing 1-3 C atoms, into a reaction zone of a relatively great ratio of length to diameter, where it is treated at a temperature of 205-300° C. for a contact time of not more than 30 minutes.

U.S.P. 2,425,754. Hydrocarbon Production. E. V. Murphree, C. W. Tyson, D. L. Campbell and H. Z. Martin to Standard Catalytic Company.

A finely divided catalyst containing a metal of the iron group and alumina is supplied to a column of substantial height and maintained in a mobile state in this column. A stream of this catalyst is passed from the bottom of the column under a pressure at least equal to the hydraulic head of the column into a reaction zone maintained at suitable reaction temperature. A mixture of hydrocarbon gas, e.g. methane, and steam is passed upwardly through the reaction zone at a velocity sufficient to maintain the catalyst in a turbulent state and to produce a suspension of the catalyst in the gas and steam. Catalyst and product gas comprising free hydrogen and oxides of carbon are withdrawn from the reaction zone. The product gas is cooled by injecting a relatively large amount of steam. The cooled product gas and steam is mixed with an iron oxide catalyst in powder form and the resulting mixture is passed into a second reaction zone to convert at least a portion of the CO in the product gas to CO_2. Hydrogen is recovered from the product gas removed from the second reaction zone.

U.S.P. 2,425,861. Catalytic Conversion of Mixtures of Alkyl Chlorides and Petroleum Fractions. H. T. Brown and E. Gorin to Socony-Vacuum Oil Company.

A mixed stream of an alkyl chloride with less than 4 C atoms and a higher than gasoline-boiling petroleum fraction containing 15-90 percent by weight of the alkyl chloride is passed through a re-

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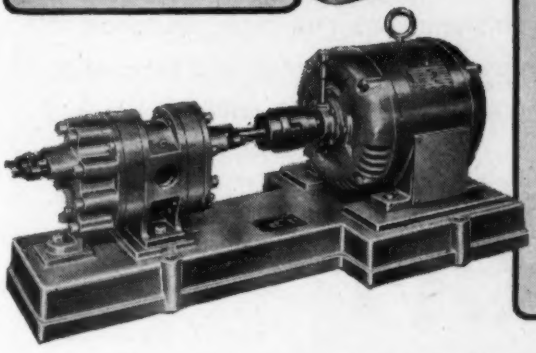

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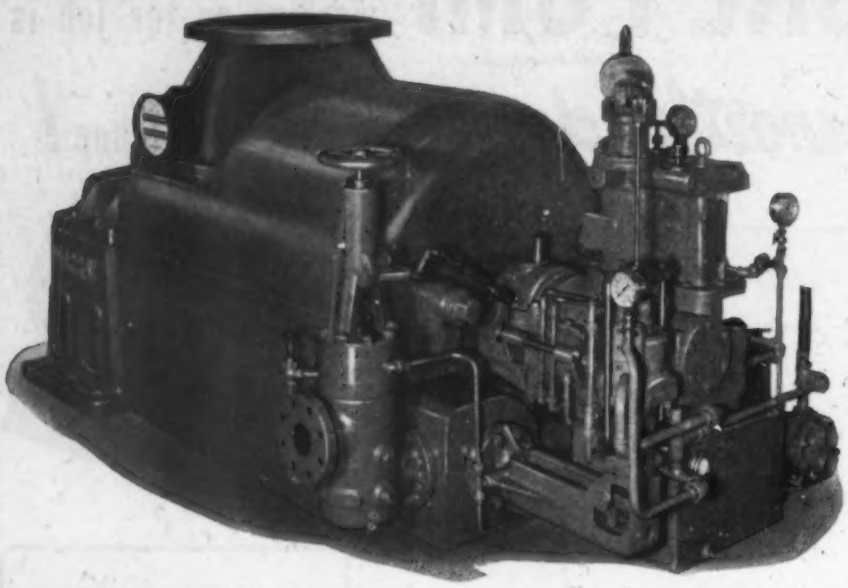

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action zone which contains an alumina-silica catalyst at a temperature of 300-450° C., at a rate such that about 50-80 percent of the alkyl chloride content of the feed mixture is converted per pass. Hydrocarbons having a greater number of C atoms than the alkyl chloride treated are recovered from the effluent stream from the reaction zone. By this process, for example, methyl chloride obtained from the methane of natural gas can be converted to a mixture of normally liquid hydrocarbons of high octane number for use as a motor fuel.

U.S.P. 2,425,969. Method and Apparatus for Conducting Gaseous Reactions in the Presence of Solid Particles. E. Utterback to Socony-Vacuum Oil Company, Inc.

Hydrocarbon vapors are converted in the presence of a particle form solid contact material which is then regenerated. For this purpose the solid material is cyclically passed through a conversion zone and a regeneration zone which are in such heat exchange relationship with each other that the maximum distance of any contact material particle in the regeneration zone from a surface of heat transfer with the conversion zone is less than about one inch. Hydrocarbon vapors are passed at a controlled rate and temperature through the conversion zone in contact with the solid contact material while preventing the flow of these vapors into the regeneration zone. Combustion supporting gas is passed through the regeneration zone in contact with spent contact material at a controlled rate and temperature to burn contaminant from this material. The regenerating gas is prevented from entering the conversion zone. Any substantial trend towards change in the range of temperatures of the contact material in both zones is selectively counteracted by adjustment of the rate of cyclic flow of the contact material, this adjustment being in a direction opposite to the direction of the trend towards change in the range of temperatures in the conversion and regeneration zones.

U.S.P. 2,426,824. Production of Synthetic Toluene from Petroleum. D. L. Fuller and B. S. Greensfelder to Shell Development Company.

A fraction of naphthenic petroleum having an initial b.p. of 185-197° F. and including the major portion of the available dimethylcyclopentanes and the methylcyclohexane (e.g. a fraction of this nature obtained by fractional distillation from California straight run gasoline) is contacted with a molybdenum oxide catalyst at a temperature of 800-1000° F. and at a liquid hourly space velocity of about 0.1-1.2 under a total pressure of 2-50 atm. with a partial pressure of hydrogen above 0.5 atm. but below that at which substantial destructive hydrogenation occurs under the reaction conditions. The production of toluene is increased by the conversion of a substantial portion of the dimethylcyclopentane as well as the methylcyclohexane to toluene. The molybdenum oxide can be supported on an adsorptive alumina carrier.

U.S.P. 2,427,112. Conversion of Hydrocarbon Oils. C. W. Tyson to Standard Oil Development Company.

In a catalytic conversion process for hydrocarbons in which solid subdivided catalyst is continuously recycled through

a conversion and a regeneration zone and the amount of heat generated in the regeneration zone by the combustion of carbonaceous deposits on the catalyst is more than sufficient to supply the heat required for conversion, excess heat formed is removed by intermixing hot regenerated catalyst of regeneration temperature with hydrocarbons to be converted in an amount more than sufficient to supply the heat for the conversion and then injecting a vaporizable cooling liquid, such as water, into this mixture in an amount sufficient to absorb the excess heat.

U.S.P. 2,427,303. Alkali Metals in Low Temperature, Friedel-Crafts Catalyzed Isoolefin Polymerization Process. J. A. Reid to Phillips Petroleum Company.

A tertiary-base olefin with not more than 7 C atoms, e.g. isobutylene, and a conjugated diolefin with not more than 7 C atoms, e.g. butadiene, are reacted together at a temperature of —75 to —200° F. in the presence of a metal halide catalyst of the Friedel-Crafts type associated with an alkali metal which is present in an amount of 25-100 percent by weight of the metal halide catalyst and is essentially unreactive as an olefin polymerizing catalyst under the reaction conditions. Sodium or potassium, or an alloy of both are preferably used for this purpose. Solid elastic copolymers of the hydrocarbons named are formed.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,425,096. Process for the Production of Trialkyl Benzene. V. N. Ipatieff and C. B. Linn to Universal Oil Products Co.

Aromatics, such as trialkyl benzene or mesitylene, are produced by dehydrating and cyclicizing a ketone, e. g. a methyl ketone at a temperature of 200-450°C. in the presence of a catalyst which comprises a heteropolyacid. This acid can have phosphorus or silicon as one component. Examples of such catalyst are: phosphotungstic acid, phosphomolybdic acid, and silicotungstic acid.

U.S.P. 2,425,098. Catalytic Conversion Process. L. S. Kassel to Universal Oil Products Co.

A plurality of vertically spaced, relatively dense fluid-like beds of solid catalyst particles is maintained at conversion temperature in a reaction zone. Hydrocarbons and subdivided catalyst particles are introduced into the lower portion of this zone. The hydrocarbons are passed upwardly in series through the catalyst beds at a velocity such as to effect substantial hindered settling of catalyst particles in each of the beds. Catalyst particles are transferred from a lower bed of the series to the next higher bed in suspension in the hydrocarbons passing from the lower to the higher bed and through a region of the reaction zone at sufficiently increased velocity to prevent hindered settling of the suspended particles in this region. A stream of catalyst particles is removed from the uppermost bed of the series and passed downwardly by gravity to the lowermost bed in a confined vertical path within the reaction zone. While in transit through this confined vertical path the catalyst stream is stripped of

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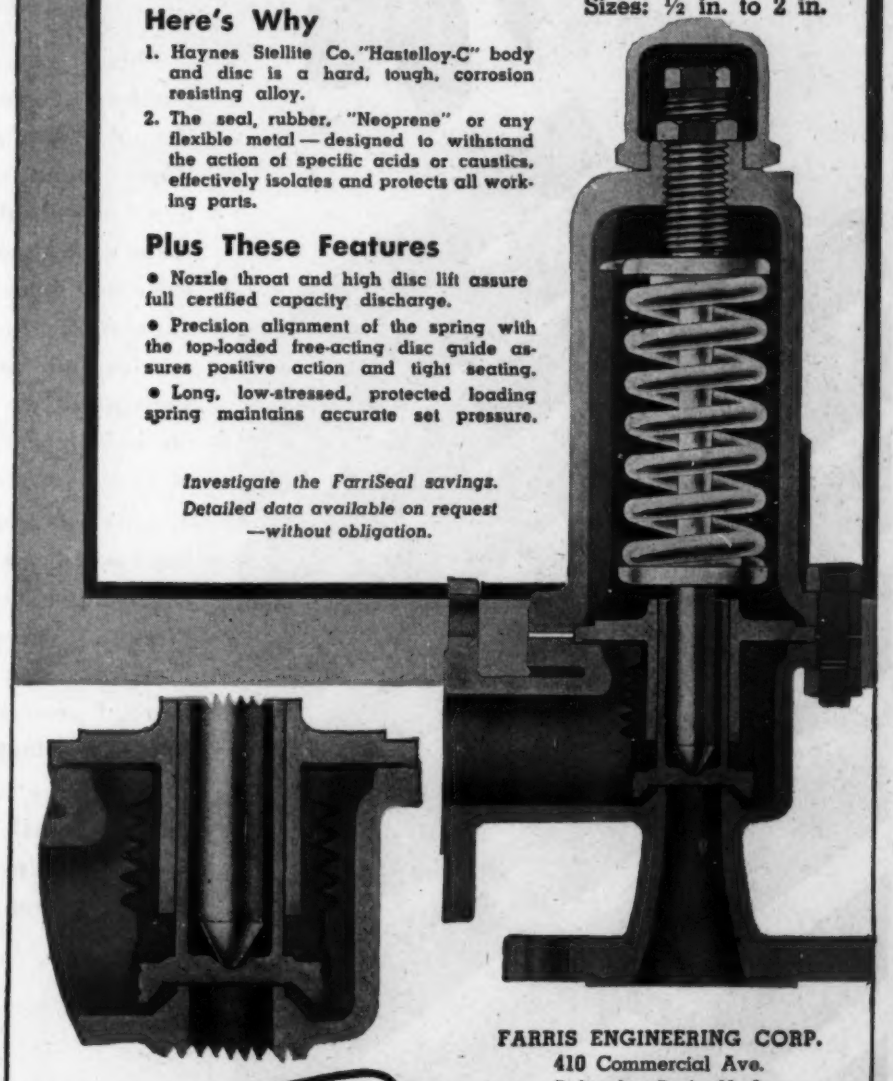

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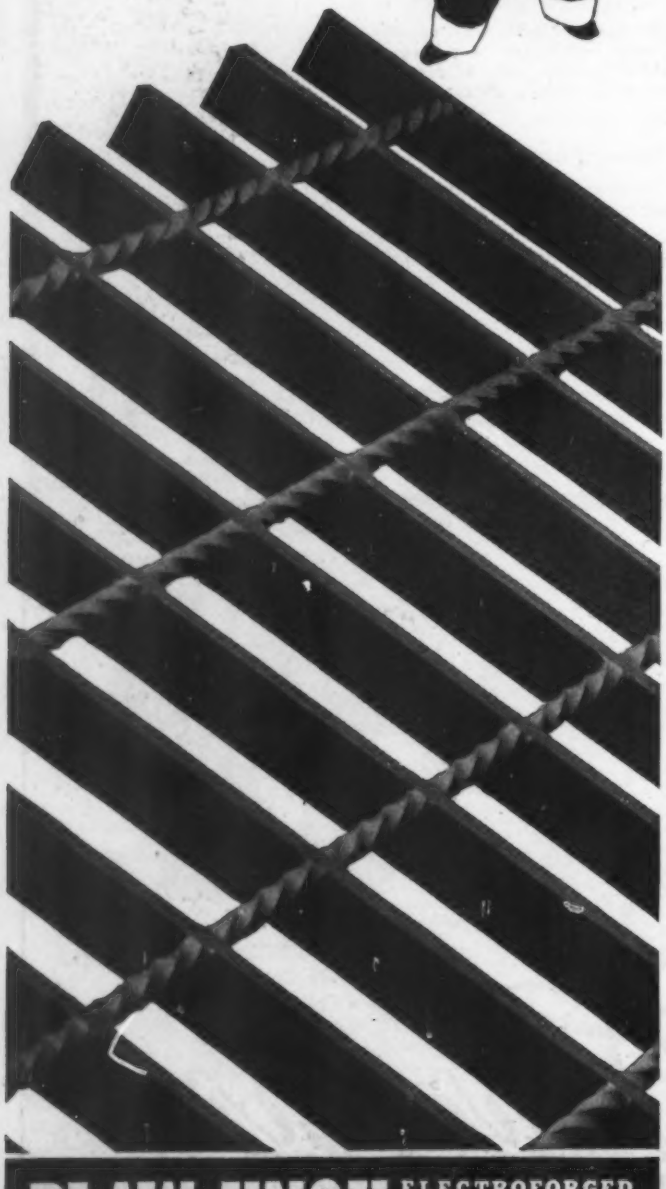

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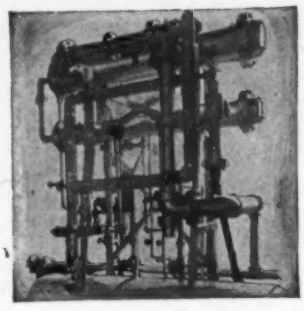

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the conversion products formed. The process is particularly useful in the dehydrogenation of hydrocarbons, such as butane.

U.S.P. 2,425,398. Manufacture of Phthalic Anhydride. R. F. Ruthruff to The Sherwin-Williams Co.

A petroleum fraction of the nature of a heavy naphtha is vaporized. The vapors are passed through a first fluidized bed of catalyst of reforming and oxidizing properties, such as V_2O_5, at reaction temperature for a time sufficient to effect extensive aromatization of the petroleum fraction. A fraction rich in dimethyl naphthalenes is separated from the reaction products and vaporized. The resulting vapors, in admixture with a gas containing free oxygen, are passed through a second fluidized bed of the catalyst under conditions suitable to convert the dimethyl naphthalenes to phthalic anhydride. Catalyst from the first bed is passed to the second bed to accomplish regeneration thereof. Regenerated catalyst from the second bed is recycled to the first bed. The regenerated catalyst is cooled to maintain the reaction temperature constant.

U.S.P. 2,426,118. Process for the Catalytic Dehydrogenation of Hydrocarbons. R. L. Parker and H. C. Huffman to Union Oil Company of California.

Hydrocarbons are dehydrogenated at elevated temperature in the presence of a catalyst comprising an activated alumina containing about 0.5-15 percent of an oxide of Si, Ti, or Zr, about 1-15 percent of BeO and a minor proportion of an oxide of a metal of group VI B, such as Cr. Butanes can, for example, be dehydrogenated by this process to butenes and butadiene.

U.S.P. 2,426,604. Removal of Acetylenic Hydrocarbons from Diolefine-Containing Mixtures. L. K. Frevel to The Dow Chemical Company.

A vaporized hydrocarbon mixture comprising a diolefin and a different alpha-beta- unsaturated hydrocarbon having no hydrogen atom on the beta C atom and having a degree of unsaturation as great as that of the diolefin, e.g. a fraction of cracked-oil gas, is passed together with sufficient hydrogen to reduce the alpha-beta- unsaturated hydrocarbon but insufficient also to reduce as much as 10 percent of the diolefin at a temperature below 300° C. over a granular catalyst consisting of 85-99.9 percent by weight of Cu intimately admixed with 15-0.1 percent of a different metal the oxide of which is reducible to the metal with hydrogen at temperatures below 550° C. Both metals of the catalyst are dispersed on an inert porous supporting material. The hydrocarbon mixture employed can, for example, comprise butadiene-1,3 and a homologue of acetylene that tends to distill therewith. Ni can be used as the second metal of the combined catalyst.

U.S.P. 2,426,829. Production of Olefins. K. K. Kearby to Standard Oil Development Company.

Mono-olefins and alkylated aromatics are dehydrogenated by means of a catalyst predominantly consisting of iron oxide promoted with a minor amount of potassium or sodium oxide. The amount of iron oxide in the catalyst can be 50-99.5 percent. Butenes or ethyl benzene

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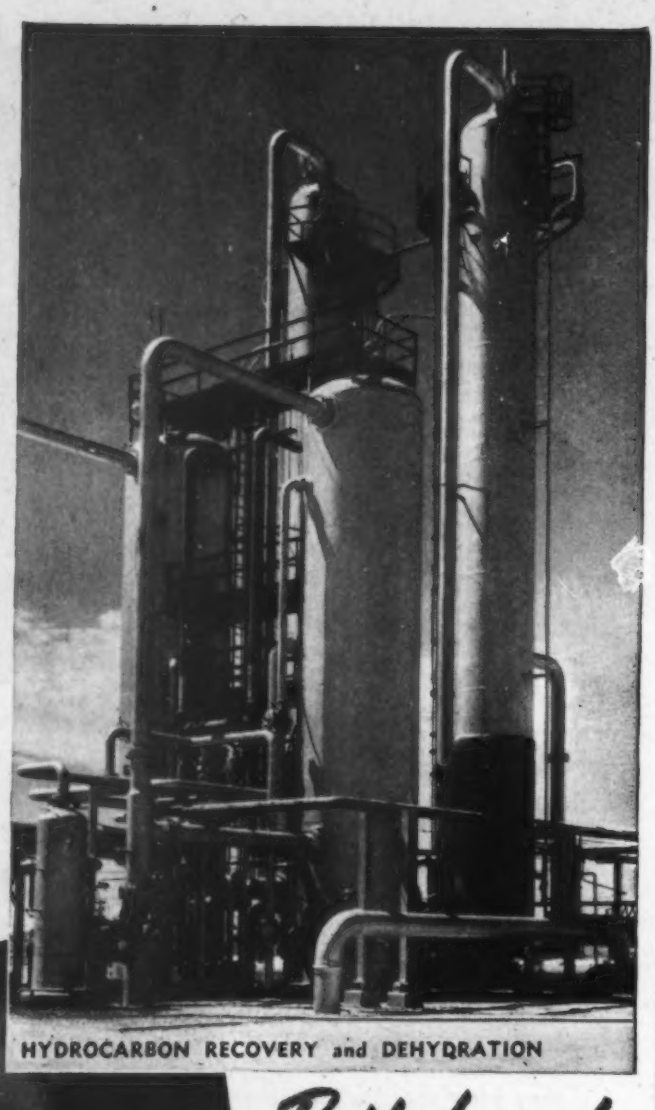

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can, for example, be dehydrogenated with high yields to butadiene or styrene, respectively.

U.S.P. 2,426,870. Process for Simultaneously Dehydrogenating Naphthenes and Hydrogenating Olefins. R. M. Hill to Standard Oil Development Company.

A hydrocarbon feed stock containing predominantly methylcyclohexane mixed with cracked heavy naphtha feed stock containing olefins is heated to a temperature of about 1000° F. and passed into an elongated reaction zone to pass lengthwise therethrough in contact with a mixed metal compound dehydrogenation and hydrogenation catalyst. At least at the start of the reaction hydrogen is admixed and preheated with the feed stock in a proportion of 10-80 mol percent. A pressure of 1 atm. to 400 psi. is maintained in the reaction zone. Sufficient olefins accurately proportioned to balance heat released by dehydrogenation are supplied at a plurality of points spaced along the reaction zone, to maintain a uniform temperature of 900-1100° F. throughout this zone. A vapor product containing toluene with gas rich in hydrogen is removed from the reaction zone.

U.S.P. 2,426,893. Butylene Dehydrogenation Process. M. W. Mayer to Standard Oil Development Company.

A feed stock comprising n-butylene, isobutylene, and n-butane is catalytically treated in a first reaction zone to dehydrogenate n-butylene to butadiene in the presence of fresh catalytic material. The product, including propane, C_4 hydrocarbons, and polymers, is removed from this zone and fractionated to separate a C_4 fraction comprising butadiene, isobutylene, n-butylene and n-butane. The butadiene is separated from this fraction, and at least a major portion of the remainder of this fraction is passed to a second dehydrogenation zone containing a less active catalyst of the same type as employed in the first zone. The operation in the second zone is conducted under temperature and pressure conditions to dehydrogenate substantial amounts of n-butylene to butadiene and to cause the decomposition by cracking of substantial amounts of the isobutylene and n-butane. A temperature of about 1150° F. can be maintained in the first reaction zone and a temperature of 1200-1300° F. in the second zone.

U.S.P. 2,426,929. Hydrogenation of Liquid Carbonaceous Materials. B. S. Greensfelder to Shell Development Company.

High boiling carbonaceous material, such as petroleum residue, shale oil, the liquid products of destructive distillation, carbonization, extraction, or other suitable treatment of coal, asphalt, pitches, and the like, is fed together with an aromatic hydrocarbon hydrogenation product and hydrogen to a reactor maintained at a temperature of at least 300° C. Reaction products withdrawn therefrom are passed to a catalyst chamber containing a hydrogenation catalyst under hydrogenating conditions. Removed reacted mixture from this chamber is flown through a noncatalytic recation zone at a temperature and a pressure at which hydrogen is transferred from the aromatic hydrocarbon hydrogenation product to the carbonaceous material undergoing treatment. The reaction products are fractionated

to separate a stream containing the dehydrogenation product of the aromatic hydrocarbon hydrogenation product, a fraction containing hydrogenation products of the reaction, and a higher boiling fraction. At least a part of the latter is recycled to the first reaction stage. The dehydrogenation product is separately hydrogenated to produce the aromatic hydrocarbon hydrogenation product for the reaction. Lower boiling hydrocarbons are obtained as the product of the process.

DESULFURIZATION

U.S.P. 2,425,776. Mercaptan Extraction. C. E. Adams and T. B. Tom to Standard Oil Company (Indiana).

Hydrocarbon distillates containing weakly acidic substances, such as mercaptans, are contacted with a solution of an alkali metal hydroxide and a solutizer comprising an alkali metal salt of a thioether acid, e.g. an acid of the formula $R_1SR_2CO_2H$ wherein R_1 is an alkyl and R_2 is an alkylene radical. The mercaptans or the like are extracted by this process. The extraction efficiency is considerably increased by the addition of the solutizer, if desired in combination with an alkali metal cresylate.

U.S.P. 2,425,777 Process for the Extraction of Mercaptans from Hydrocarbon Oils. C. E. Adams and T. B. Tom to Standard Oil Company (Indiana).

The process of this patent is similar to that of U. S. Patent 2,425,776. An alkali metal salt of a polyether acid is used as the solutizer in this case, e.g. an acid of the formula $R_1—X—(R_2X)_r—R_2—CO_2H$ wherein R_1 is an alkyl or substituted alkyl radical, R_2 and R_3 are alkylene radicals, X is an element of group VI of the periodic system with atomic numbers 8-16 and Y is a simple whole number. Ethoxy - ethoxy- a cetic acid is an example of such an acid.

U.S.P. 2,427,083. Process for Removing Weakly Acidic Substances from Oils. C. E. Adams and T. B. Tom to Standard Oil Company (Indiana).

Weakly acidic oils, particularly such containing mercaptans, are extracted with an aqueous solution of caustic alkali and an alkali metal salt of an N-substituted amino acid in which the nitrogen is attached to at least one hydrocarbon radical. The concentration of the caustic alkali can, for example, be 5-25 percent and that of the amino acid 5-35 percent. The amino acid serving as a solutizer can, for example, be a dimethyl-, diethyl-, or dipropyl aminoacetic acid, butylaminoacetic acid, or the like. Substituted amino acids with 3-8 C atoms are generally preferred.

U.S.P. 2,427,250. Sweetening of Hydrocarbon Liquids. D. C. Bond to The Pure Oil Company.

A hydrocarbon liquid containing mercaptans is saturated with air and then contacted with an aqueous alkali solution containing a small amount of an organic oxidation catalyst capable of promoting oxidation of mercaptans and susceptible to destruction upon oxidation. A phenolic substance capable of being oxidized to the quinone form, can, for example, be employed for this purpose. The major portion of mercaptans can be extracted from the liquid, prior to contacting it with air, by means of an aqueous alkali solution containing free alkali metal hydroxide.

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U.S.P. 2,423,789. Pour Point Depressant for Lubricating Oils. T. G. Murphy and J. Faust to L. Sonneborn Sons, Inc.

The patent relates to a pour point depressant for addition to a wax containing petroleum hydrocarbon oil which normally has a relatively high pour point. The depressant comprises more than 30% petroleum hydrocarbon oil carrier, about 4-48% aluminum stearate and about 2-15% P_2S_5 reacted alkali metal petroleum mahogany sulfonate, both dissolved in the petroleum carrier. In contrast to aluminum stearate when employed for itself alone as a pour point depressant, the pour point obtained by the new, combined depressant is not fugitive and, therefore, does not revert upon storage or in service progressively to the pour point of the original oil.

U.S.P. 2,423,913. Composite Fuel and Method Preparation. R. S. Vose to Sun Oil Co.

Finely divided carbonaceous particles are dispersed in a liquid hydrocarbon fuel oil. The resulting mixture is heated, while maintaining the carbonaceous particles in suspended state, to a temperature above 150°F. but below the cracking temperature of the oil for such a period of time as to bring about a relatively sudden marked increase in viscosity. The fuel thus obtained is characterized by stability with respect to settlement of carbonaceous particles even when diluted with a substantial proportion of added liquid hydrocarbon fuel of relatively low viscosity. Such dilution can be made to increase fluidity of the fuel to the degree required to render it flowable without pumping and preheating. A residual type fuel oil can, for example, be treated by this process with at least 30% of carbonaceous particles.

U.S.P. 2,425,747. Lubricating Oil Composition. E. Lieber and M. E. Thorner to Standard Oil Development Company.

The lubricating composition comprises a major proportion of a lubricating oil base stock and a small amount of a condensation product of an aliphatic monohydroxy alcohol with less than 7 C atoms and an aromatic compound with less than 4 aromatic nuclei. This condensation product, e.g. polyamylated naphthalene, shall be non-volatile at about 600° F. under reduced pressure and has the property of depressing the pour point of waxy mineral oils.

U.S.P. 2,425,791. Electric Oil. E. S. Flynn to Anaconda Wire & Cable Company.

The electric insulating oil according to this patent consists of a highly refined mineral oil stabilized against the deleterious action of micro-organisms by incorporation of about 0.05-0.2 percent by weight of naphthoquinone. This oil is particularly suited as an impregnant in oil-filled electric cables.

U.S.P. 2,426,496. Corrosion Protecting Compositions. F. F. Farley to Shell Development Corporation.

A neutral fluid vehicle, such as a liquid hydrocarbon, is mixed with a minor,

corrosion-inhibiting amount each of a half-neutralized and an unneutralized dibasic aliphatic dicarboxylic acid with at least 12 C atoms. The two acidic groups of the compound are separated by not more than 4 intervening atoms. The half neutralized dicarboxylic acid is an ammonium or alkali metal acid salt. Both of the acidic radicals can be carboxylic radicals or their thio equivalents. The protective effect of the additive is particularly pronounced toward ferrous metals.

U.S.P. Re. 22,909. Antioxidant. W. M. Smith and C. J. Wilson, to Standard Oil Development Co.

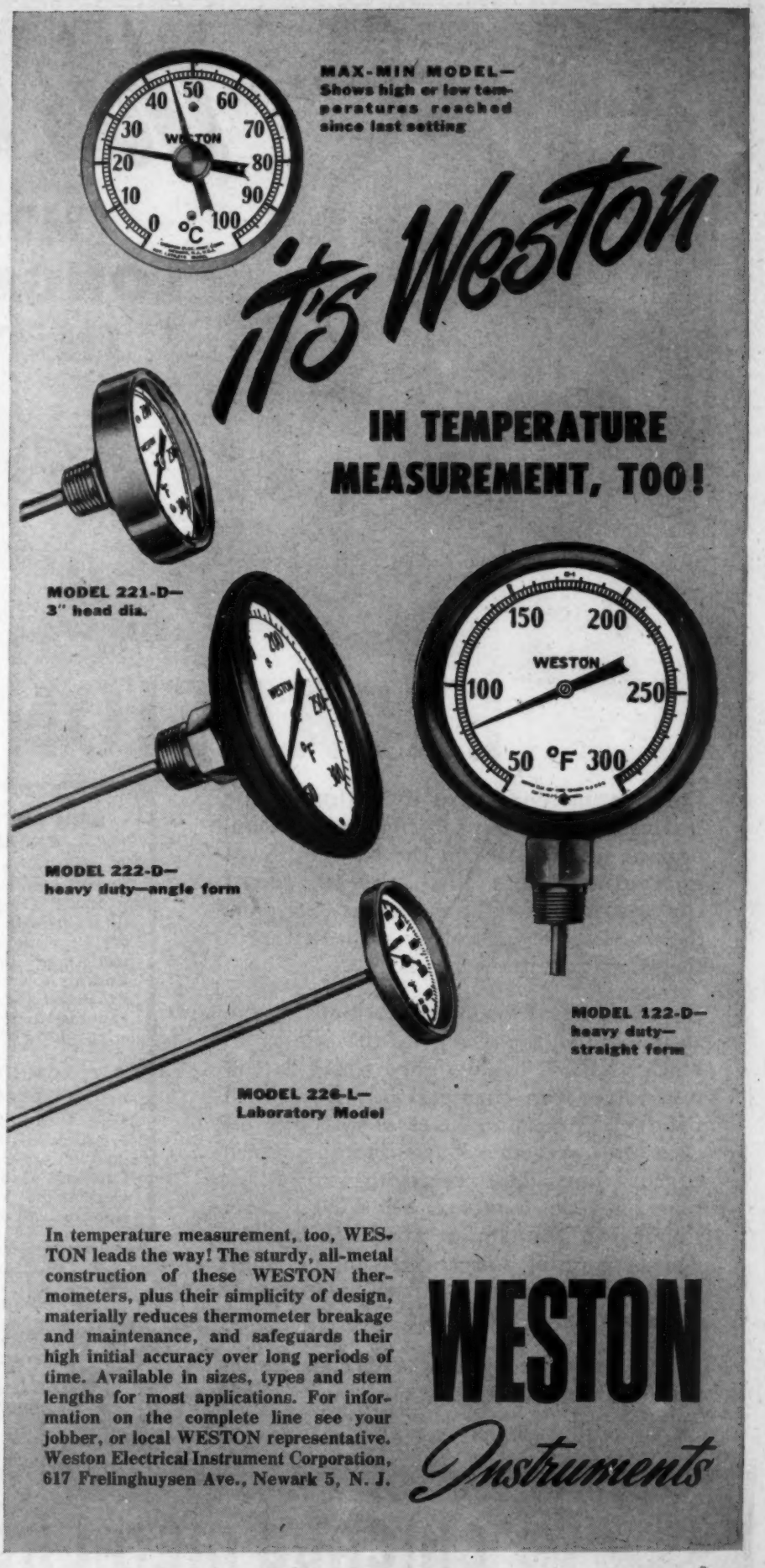
A mineral oil, e.g. a lubricating oil or a gasoline is described which contains a small amount of a product formed in the following manner. First p-cresol is reacted with isobutene in the presence of a catalytic amount (e.g. 5 percent by weight) of H_2SO_4 of about 96 percent concentration at a temperature of about 70° C., the quantities of p-cresol and isobutene being such and the reaction being carried to such point that a product with a mol. wt. of about 220 and an approximate empiric formula $C_{15}H_{24}O$ results. This product is then submitted to aldehydic oxidation by contacting it with an alkali dichromate solution in the presence of H_2SO_4 and at a temperature of 70-80° C. By the addition of the product thus obtained which contains an aldehyde group the mineral oil is stabilized against oxidation by atmospheric oxygen.

Re. 22,910. Lubricating Compositions. J. G. McNab, C. J. Wilson, and C. Winning to Standard Oil Development Company.

A mineral lubricating oil base contains a small amount of a product formed by reacting p-cresol with isobutylene or tert. butyl alcohol in the presence of a catalytic amount of H_2SO_4 of about 96 percent concentration. The quantities of the two organic components used are such and the reaction is carried out under conditions such that a product with a mol. wt. of about 220 and an approximate empirical formula of $C_{15}H_{24}O$ results. A small amount of Ba bis-(tert.-octylphenoxy) sulfide or disulfide, or of a corresponding compound of another metal of group II of the periodic table is added. The p-cresol isobutylene reaction product, which can, for example, be added in an amount of 0.5 percent to the lubricating oil, serves as a stabilizer, while the sulfide used in an amount of about 0,5 percent imparts detergent properties to the composition.

Re. 22,911. Lubricant. J. B. Stucker to The Pure Oil Company.

A mineral lubricating oil has incorporated minor proportions of (1) sulfurized-phosphorized or phosphorized fatty material, and (2) of organic polysulfides in which the sulfur is linked between two radicals of aryl, aralkyl, or alkyl; dialkyl polysulfides with less than 6 C atoms in the combined alkyl radicals, however, being excluded. Material (2) is present in an amount of 2-5 percent, while material (1) is present in greater quantities, e.g. 10-20 percent. The load carrying ability of the lubricating oil is improved by these additions. A sulfurized and phosphorized lard oil and dibenzyl disulfide can, for example, be used as the combined additives.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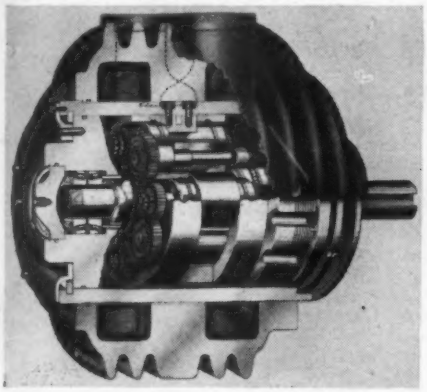
1—Rotocycle Pump

A new rotary, positive displacement pump has been developed by the Hydraulics Division of Rockwell Manufacturing Company, 50 Water Street, Pittsburgh 22, Pa. It is of the fixed volume, double acting type with all operating parts held in hydraulic and dynamic balance.

The rotor assembly is suspended within the pump body on a horizontal drive



shaft. The rotor carries four, half-moon shaped impeller vanes geared together in the ratio of 2 to 1 equally spaced on its outer circumference. As the rotor is turned by applied torque, the position of these vanes varies with respect to the sidewalls of the circular pumping chamber—always, however, so that each pair of diametrically opposed vanes forms two closed compartments per rotating cycle. There is a fixed, closely held clearance between the circumference of the impeller vanes, the sidewall of the pumping chamber and the rotor.

2—Thickness Gauge

A precision instrument for measuring corrosion and wall thickness from one side of metallic surfaces is announced by Scott Electroflux Company, 400 Main Street, Waltham 54, Mass. Electroflux is designed for the non-destructive inspection and testing of metallic containers, vessels and piping while in service. It measures thickness within 3 percent of actual thickness, is portable, weighs 55 pounds.

3—New Type Welder

A new type of welder for the manufacture of composite or clad plates used in pressure vessels and a new variation of the slabbing process for bonded composite plates have been announced by The Babcock & Wilcox Company, 85 Liberty Street, New York 6.

Operation of the new welder is characterized by more consistent welding voltage, considerable power savings, and higher current flow into the work for shorter periods. It helps overcome the problem of shunt currents and contact resistance, the company explained. Two rotary type transformers are used in contrast to the conventional transformer which is stationary, and a pulsating current to the weld is obtained by means of a pulsation timer.

A new variation of the slabbing process has also been developed recently. The Babcock & Wilcox Company announced. The method is believed to be applicable to most alloys and non-ferrous materials.

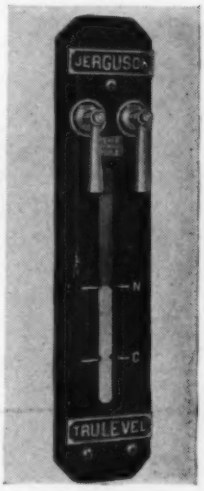
4—Weed Exterminator

A new product, "General Weed Exterminator," has been announced by General Petroleum Corporation, 108 W. Second Street, Los Angeles. The highly aromatic synthetic product was developed in the company's own laboratories and has been under test over a considerable period on experimental farms, etc. It may be applied to wet or dry weeds with equal effectiveness.

5—Remote Reading Gage

Jerguson Gage & Valve Company, 80 Fellsway, Somerville 45, Mass., has announced its new "Trulevel" gage which "can be read and quickly checked at the remote reading point. The gage is provided with a new type of datum column located at the drum, this datum column being fully steam jacketed, duplicating the temperature and specific gravity conditions existing in the boiler drum. Accuracy thus is assured, according to the company's announcement.

An illustrated data unit No. 38 covering the Trulevel Gage will be sent upon request.

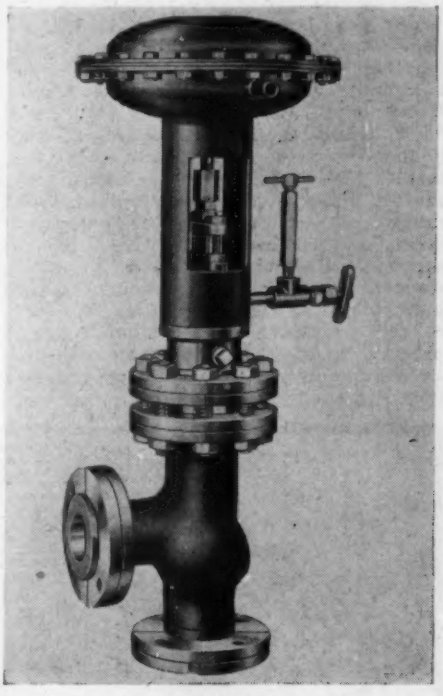


Trulevel Gage

6—Diaphragm Control Valves

Hammel-Dahl Company, 243 Richmond Street, Providence 3, R. I., announces a new line of Venturiflo diaphragm control valves, the primary design of which incorporates a Venturi throat which "insures the optimum in streamline flow characteristics." These valves are designed primarily for high pressure applications and can be used on the current Fluid catalytic crackers, as well as many operations on the synthesis of oil from gas on current Fischer-Tropsch process plants.

The basic concept of design is to have



a cast bowl type angle body which will insure no increase in flow velocity as the fluid leaves the piping and enters the valve body. The valve body itself conforms to ASA face to center-line dimensions. The friction factor in this type valve body is said to average 5 in comparison with a friction factor of 9 in usual globe or double-seated control valves. The valve plug is top guided and centered in the seat both by the mechanical guiding and the flow of fluid through the valve body.

Positive identification of new equipment bulletins by name and number listed in Petroleum Refiner insure prompt replies to your requests for literature and information.

7—Moisture Meter

The Thwing-Albert Electronic Instrument Company's (Penn Street and Pulaski Avenue, Philadelphia 44), % Moisture Meter is a battery operated instrument which measures the resistance to the flow of an electric current, this resistance changing with the moisture content of the material being tested. The current flow through the meter is amplified by the use of an electronic circuit, and the readings are indicated on a scale reading directly in terms of per

cent moisture. It has been designed for use as an industrial production tool, rather than a laboratory instrument.

New Davis Vapotester

8—Vapotester

For the determination of hazardous conditions due to the presence of combustible or explosive concentrations of flammable gases or vapors, the Davis Emergency Equipment Company, Inc., 45 Halleck St., Newark 4, N. J., announce its new supersensitive "Vapotester" Model 6, a two range instrument said to increase sensitivity tenfold. One range analyzes combustible gases in terms of their lower explosive limit. A second scale indicates gases in their toxic range. The basic principle of the indicator is the measurement of increases in the resistance of a filament when exposed to a gas or vapor-air mixture as compared with a filmament not exposed to such gas or vapor-air mixture.

9—Pipe Clamp

Grinnell Company, Inc., Providence 1, R. I., is supplying high-temperature pipe clamps in seven sizes from 4 to 16-inches, made of Chrome Vanadium Steel as a one-piece drop forging and equipped with a U-Bolt of the same material. These are expected to meet most high-temperature pipe clamp requirements at temperatures up to 1000° F., without a high cost penalty, the company says.

10—Miniature-Size Recorder

A miniature-size temperature recorder, designed for use in the many applications where a shock-resistant, easily portable temperature recording instrument is necessary, has been announced by C. J. Tagliabue Mfg. Company, Park and Nostrand Avenues, Brooklyn, N. Y., a subsidiary of Portable Products Corporation. A special transparent, unbreakable plastic front permits full view of entire chart and pen-arm. The instrument is available in models to operate in a wide variety of ranges and 7-day spring propelled mechanism with charts of 24 or 72-hour duration. Overall dimensions are: 5¾ inches square, 4¼ inches deep, and total weight is less than 3½ pounds.

One of GE's New Motors

11—Stepless Speed Adjustment Motor

A new line of Tri-Clad brush-shifting adjustable speed induction motors, Type ACA, has been announced by the Motor Divisions of the General Electric Company. Available in ratings from 3 to 50 hp (220, 440, and 550 volts), the new motor features stepless speed adjustment over a 3:1 ratio by simply turning a dial. The entire unit, with the exception of the starter control, is self contained

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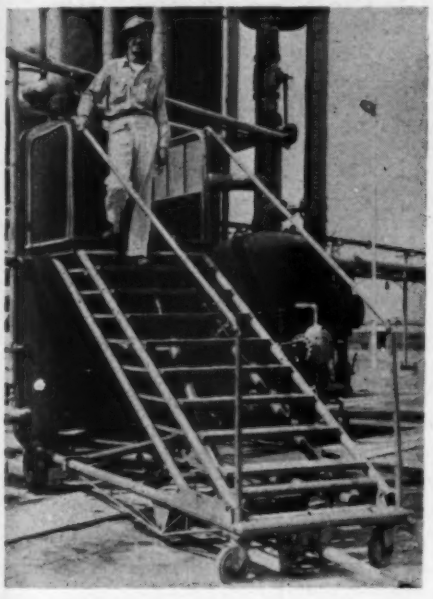
in a housing only a little larger than that for a constant-speed motor of comparable rating.

Remote speed control can be accomplished by use of a flexible cable shaft up to 10 feet away from the motor. For complete remote control, a small pilot motor can be used to drive the speed control mechanism.

Bulletin GEA 4854 gives further details.

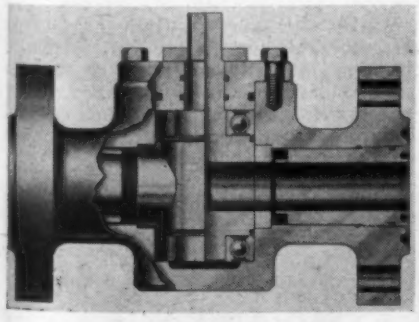
12—"Aerostand"

"Aerostands," hydraulically adjustable workstands, used by refinery maintenance crews in the repair of overhead pipe lines, valves, wiring, etc., provide platform working heights within the range three feet to 24 feet above ground level. Steps to the platform are self level-



ing at all heights. Tow bar and steady braces are optional accessories to the ten-foot Aerostands. A static load capacity rating of 1500 pounds on the platform is claimed.

Details are available from Airquipment Company, 2820 Ontario Street, Burbank, Calif.



LJS Plug Valve

13—Non-Lubricated Plug Valve

A new, quick-opening high-pressure fluid control valve, the "LJS Plug Valve" is in production at Johnson Foundry and Machine Company, 1119 North Main, Los Angeles 12. Featured is a straight, non-tapered plug that requires no lubrition and is suspended top and bottom on

"For a fire in here, the extinguishing agent must be non-damaging"

If a blaze breaks out in your correspondence files—or blueprint storage room—*putting out* the fire can cause more damage than the fire itself. But not if your extinguishing system has been recommended by a Kidde representative!

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Walter Kidde & Company, Inc., 1148 Main Street, Belleville 9, N. J.

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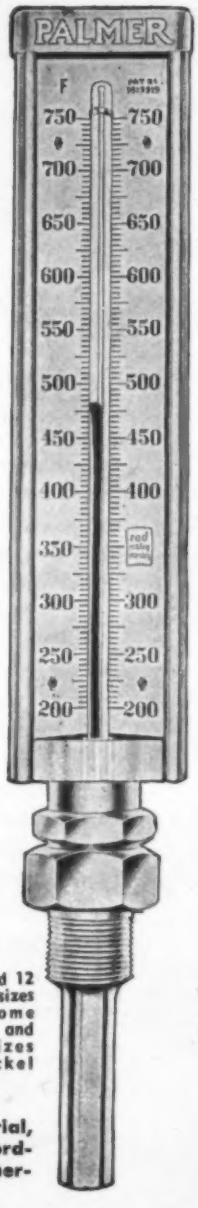
• The latch string is out . . . send for "The Story of Palmer Thermometers" . . . yours for the asking!



In 7, 9, and 12 inch case sizes with chrome finish; in 4 and 6 inch sizes with nickel finish.

PALMER THERMOMETERS INC.

Mfrs. of Industrial, Laboratory, Recording and Dial Thermometers.

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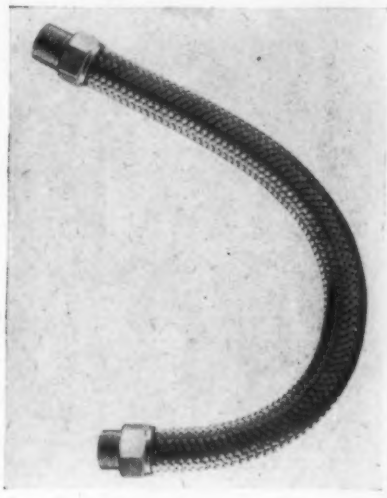
CANADIAN PLANT: KING AND GEORGE STS., TORONTO 2

sealed ball bearings which take the thrust radially. This plug is the only moving part. A quarter turn opens and closes valve at high pressures and temperatures, requiring very little torque. Flange and screw type are available in ferrous, non-ferrous and special metals for every type of industrial use.

14—Flexible Tubing

Flexible metallic tubing made from monel metal for use where severe corrosion or high temperatures are encountered, is announced by Titeflex, Inc., 674



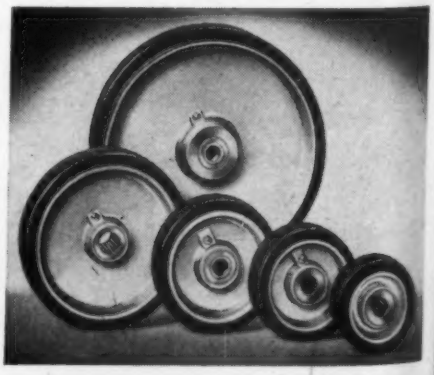
Frelinghuysen Avenue, Newark 5, New Jersey.

Known as "Titeflex" monel the tubing is supplied for four temperature ranges, depending upon the melting point of the solder used in the seam of the inner core (358 to 1785° F.). It is supplied in the same sizes and with the same types of fittings as the standard Titeflex brass flexible tubing.

15—Aluminum Alloy Wheels

A new line of aluminum alloy industrial wheels of compact design and in a complete range of sizes from four to twelve inches in diameter is announced by the Airlite Division of the Aerol Company, Los Angeles, manufacturers of modern materials handling equipment.

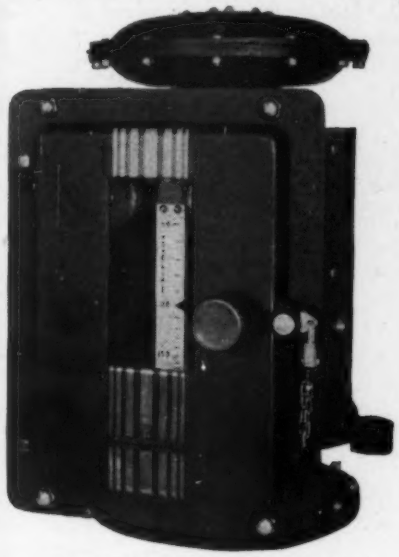
Marketed under the trade name Airlite, the new wheels are available with either a molded on Grade A rubber tread or an all aluminum tread. They are corrosive resistant and their special design permits easy, free rolling even with maximum loading.



Aluminum Alloy Wheels

16—Air-Fuel Controller

Complete L&N temperature and combustion control systems for large industrial furnaces now include a new air-fuel ratio controller which, like the micromax pyrometers and L&N furnace pressure controllers with which it operates, employs electric-motored valve drives—needs no hydraulic piping. This controller is said to be a rugged, balance-type instrument, having ample flexibility



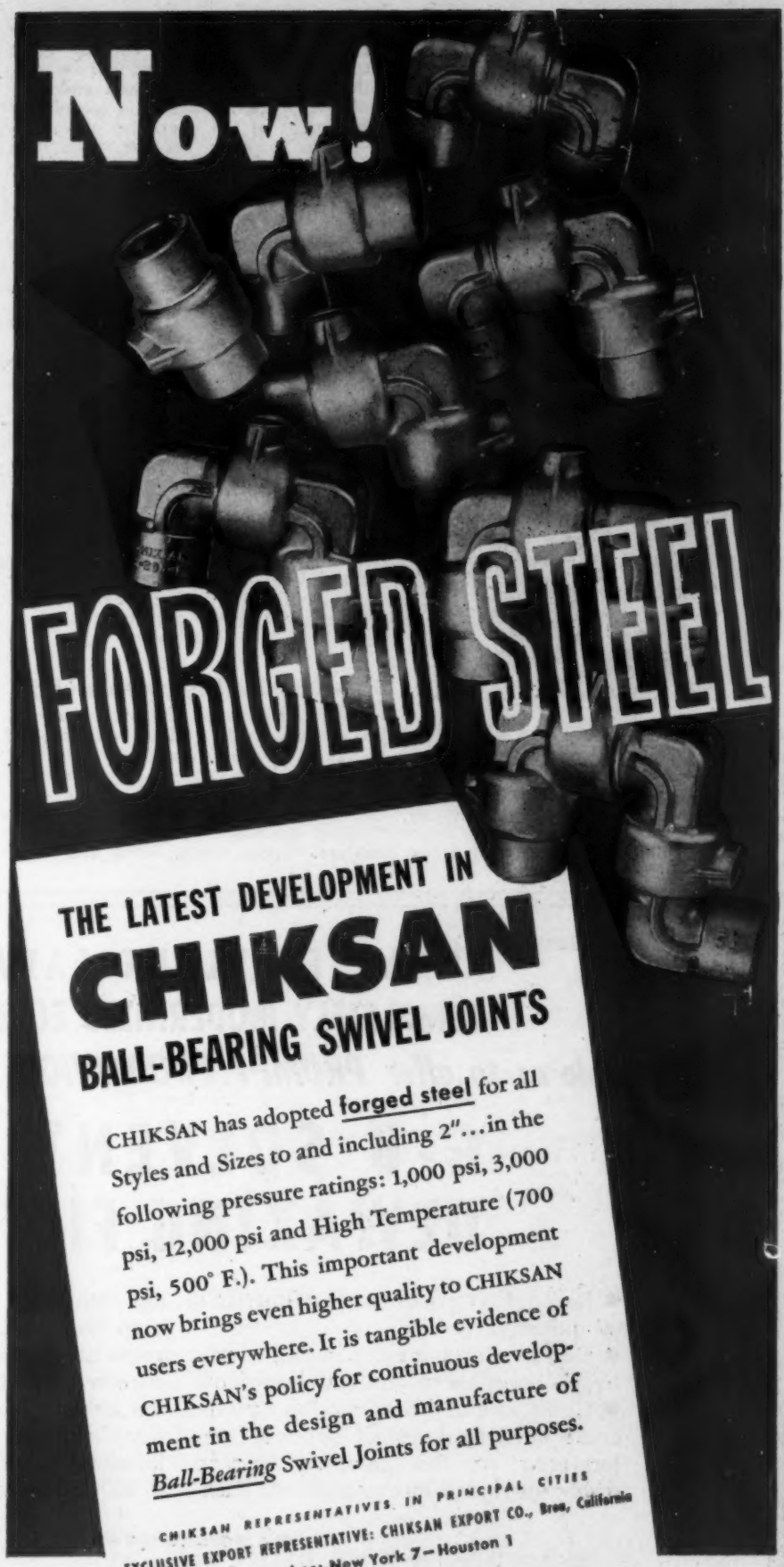
L & N Air Fuel Ratio Controller

to meet any operating condition. It mounts readily on the furnace panel along with other L&N control instruments. Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44.

17—Duplex Sediment Strainer

A new type duplex or twin sediment strainer, developed by J. A. Zurn Manufacturing Company, Erie, Pa., was designed to meet the demand for an economical strainer in pipe lines where continuous flow is imperative. When the strainer is to be cleaned, flow can be diverted from one basket to the other without interrupting passage through the strainer. The unit operates by means of a single plug type valve whose orifice direct flow from the inlet to either basket, or both simultaneously. The seating of the plug into the body is regulated by

Duplex Sediment Strainer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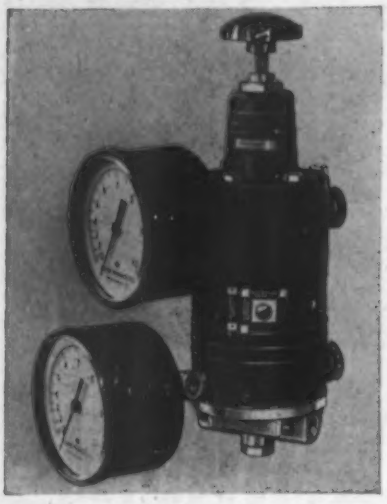
the relieving yoke which acts to seat the plug tightly for sealing, or to loosen it for turning, as required.

18—"Nullmatic" Controller

Moore Products Company, H & Lycoming streets, Philadelphia 24, announces its "Nullmatic" controller, a new control instrument which operates on the company's "null" balance system, and which makes it possible to use



pneumatic force-balance for the entire controlled system. All friction-producing parts have been eliminated from the control circuit and a number of other design improvements have been incorporated.

The controller operates directly from the process transmitter, and sends an output pressure to the control valve without introducing frictional errors, with their resulting dead-spot and controller lag. Control action is completely independent of the operation of the indicator or recorder, because these units are outside of the control circuit.

19—New Paint

A revolutionary new paint, made from a water dispersion of a synthetic resin instead of customary drying oils, dries in less than half an hour without odor, yet possesses the durability and finish of high class oil paints, according to Foster D. Snell, Inc, 29 West 15th Street, and Shawinigan Products Corporation, both of New York.

The vehicle of the new paint is a dispersion of totally synthetic poly-vinyl resin in water and is expected, the announcement said, to help free the paint industry from dependence on natural oils and resins. The new product is designated by the trade-mark "Gelva" paint.

The pigment and poly-vinyl resin are dispersed in water with one percent or so of a synthetic wetting agent. It can be brushed or sprayed on in the same manner as an ordinary paint.

20—Gas Combustion Assembly

A new line of complete, pre-engineered gas combustion assemblies is announced by the Industrial Division, Bryant Heat Company, 1020 London Rd., Cleveland 10, Ohio. Called the Bryant "Pow-R-Semblies," the new packaged units are "ideally adapted to firing boilers, air heaters, dryers, ovens, kilns, and wherever semi-open burners with controlled flames are desired." Heart of the new unit is the newly developed "Mixjector," compact proportional mixing device. The assemblies are available in eight capacities.

21—Ni-Resist Gate Valves

Crane Company, 836 South Michigan Avenue, Chicago, announces the reinstatement of its line of Ni-Resist Cast

Iron Gate Valves, which was discontinued prior to the war.

The valves are of the wedge disc, outside screw and yoke type and are being

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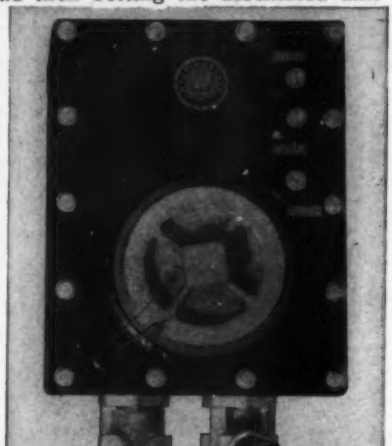
BIRMINGHAM, ALABAMA
NEW YORK—Goslin-Birmingham, 350 Madison Ave., New York 17, N. Y.

regularly furnished with screwed ends in sizes from ½ to 2 inches and with flanged ends in sizes from 1 to 8 inches. All valves in sizes 3 inches and smaller have the clamp type bolted bonnet and sizes 4 to 8-inch inclusive have the conventional type of bolted bonnet.

The strength and physical characteristics of Ni-Resist are about the same as those of cast iron; but resistance to erosion and wear is definitely superior to that of cast iron, and corrosion resistance is substantially better, Crane declares.

22—Explosion Tested Linestarter

A new explosion-tested linestarter, said to incorporate many improvements, a few of which are: rugged d-c magnetic contactor with knife edge bearings; packing glands that can be bolted in place permitting the assembly of conduit and gland away from the starter and then bolting the assembled unit to



the starter; a hand hole in the cover to facilitate replacing fuses or heaters; an overload relay that can be arranged for either manual or automatic resetting; and, a smaller enclosure is available from Westinghouse Electric Corporation, Pittsburgh, Pa. It is for use with d-c motors up to 5 hp on circuits of 80, 115, 230 and 550 voles which may be safely started by connecting directly to the line.

These linestarters have passed all the tests of the U. S. Bureau of Mines for "explosion tested" equipment.

23—Centrifugal Pump

Incorporating a number of refinements in design to meet needs suggested by industrial users of pumps handling acids and caustics, Peerless Pump Division, Food Machinery Corporation, 301 West Avenue 26, Los Angeles 31, has developed a new centrifugal pump, designated as Type ACO "to help reduce costs of pumping corrosive fluids through ease of handling, prevention of corrosion to pump parts and lower unit maintenance." Ask for Bulletin D-2400.

24—Propane, Butane Hose

A new rubber hose with increased strength and lighter weight has been developed by United States Rubber Company, Rockefeller Center, New York, for handling propane and butane petroleum gas.

The hose is made of a special synthetic rubber rubber compound capable of resisting the effects of liquefied petroleum gas. It is reinforced with "Ustex" yarn, a chemically treated cotton textile having high strength and low stretch characteristics. The hose will be molded in continuous lengths in three sizes—one-half inch, three-quarter inch and one inch i.d.

When writing the manufacturer of new equipment for literature or more information identify his product by name and number listed in Petroleum Refiner.

25—Revolving Crane

Mounted on a Model UTI Minneapolis Moline Tractor, the Joshua Hendy Type U crane distributed by Industrial Equipment Company, 4441 Santa Fe Avenue, Los Angeles can travel wherever a tractor can go. It has a high lifting capacity of from 1½ to 4 tons, yet its builders state that it offers easy steering, due to its special steering gear with roller-bearing knuckles. Enclosed stabilizers permit full front axle movement for smoother traveling, yet provide positive support when swinging a load. Front end construction includes a 72-inch axle, heavy steering spindles and reach rod, and heavy cast wheels.

The all-welded steel boom is raised and lowered by a hydraulic cylinder mounted on the gantry and controlled

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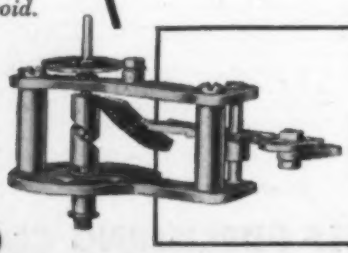

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by a valve at the right of the steering wheel.

The operator's seat is offset to provide full visibility for traveling or crane operation. In addition, the tractor has a rear power take-off and pintle hook drawbar at the rear so that it can be used for many other purposes when crane work is slack.

26—New AC Welders

The Harnischfeger Corporation, Welding Division, 4400 West National Avenue, Milwaukee 14, Wis., has announced a complete new line of AC arc welders.

Designed and built by P&H, the welders are supplied with "Dial-lectric" con-

trol, which elimintes the need for moving coils or cores, worm gears, sprockets and chain or lever adjustments. It is said by P&H that there isn't a single moving part in the entire machine.

All industrial models of this new P&H series are designed for remote control, made possible by a removable control dial. Another improvement is the high-low welding range.

Literature describing these welders is available.

27—Gas Alarm System

Davis Emergency Equipment Company, Inc., 45 Halleck Street, Newark 4, N. J., has announced new developments in their continuous, combustible gas alarm system (remote head type).

The system was designed to detect the presence of combustible vapor and or gas and to give an audible signal before the mixture becomes dangerous.

The Davis system is built on the unit plan. When more than one sampling points are required, two or up to six control cabinets are used. Each cabinet has its own analyzer head but all are served by the same pump.

28—Drum Pump

A new hand pump which utilizes the diaphragm principle, has been announced by General Scientific Equipment Company, 27th & Huntingdon Streets, Philadelphia 32, Pa., as the last word in

pump efficiency and sturdiness. It pumps (from a barrel) 15 gallons of light oil per minute, requires no priming and has no leather or rotating parts. The pump screws directly into the drum and so separate bung bushings are required for 1½ or 2" drum openings.

Helicoid Gage Case

29—Gage Case

Helicoid Gage Division of American Chain & Cable Company, Bridgeport, Conn., has announced a newly developed gage case made of a high compression molded aluminum alloy. Called the "Acaloy" case, the surface is treated by a patented process to prevent corrosion, and it is claimed that the case will withstand 1500 hours salt spray test. Over this treated surface there is a black baked-on finish. The case is claimed to be weather-proof since it is provided with a synthetic rubber sealing gasket and a stainless steel snap ring. This new case is designed to accommodate safety blowout discs, which are supplied when required.

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

30—Welding Apparatus Case

Air Reduction Sales Company, 60 East 42nd Street, New York 17, has announced an improved carrying case for transporting a welding or cutting outfit. Torch, tips, regulators, hose, gloves, goggles, wrenches and miscellaneous equipment can all be compactly arranged in this case, which is constructed of 22 gauge cold rolled steel with flush double lock seams. The case 22 x 8 x 9 inches, has a net weight of 10½ pounds.

31—Storm Suit

A new lightweight storm suit made with its Ameripol, American-made rubber is announced by The B. F. Goodrich Company, Akron, Ohio. The suit affords maximum protection from wind and rain in many industrial applications.

The two-piece suit has a hooded parka, raglan sleeves, gusseted neck with waterproof slide fastener from chest to neck. It is water, acid, alkali and caustic proof and is resistant to gasoline, grease, animal and vegetable fats, will not stiffen or crack and is extremely comfortable for this type garment.

32—V-Belting by Piece

Plant engineers and other users now can buy open-end V-belting by the foot or yard, Goodyear Tire & Rubber Company, Akron, Ohio, which is supplying the belting in reels of 450 to 550-foot lengths, has announced.

Using special fasteners to splice the open ends, making an endless power-transmission belt, the V-belts thus can be formed to proper size for emergency use and special adaption. The fasteners are installed with specially-designed tools. Standard top widths of 21 thirty-seconds, seven-eights, and one and a quarter inches are available.

33—X-Ray Photometer

Economical and rapid means of making chemical comparisons is provided by a new instrument known as the X-ray photometer. With this device it has been found possible to determine satisfactorily the tetraethyl lead content of gasoline, the concentration of an acid in water, the percent chlorination of a plastic, or the percent ash in coal. These determinations are made by measuring

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and comparing the X-ray absorption of a sample and a reference.

The complete apparatus is housed in a mobile cabinet of moderate size, and can be operated by any reasonably competent technician. The analysis is made without loss or alteration of the sample tested.

In its present commercial form the X-ray photometers are available only in a manual type but recording and self-balancing features can be added when desired. General Electric Company, Apparatus Division, Schenectady 5, N. Y.

34—Pressure Valves

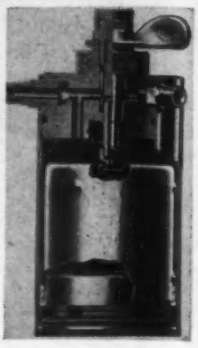
Designed for high-pressure service, the new "N-M-D" non-metallic disc bronze valve has been announced by The Lunkenheimer Company, Cincinnati 14, Ohio. Made in globe, angle and check patterns, sizes ¼ to 3 inch, screw ends, the valves are constructed to withstand pressures up to 400 pounds, water, oil or gas. Disc and stem packing are especially compounded for LPG service. All patterns are illustrated in Circular 576.

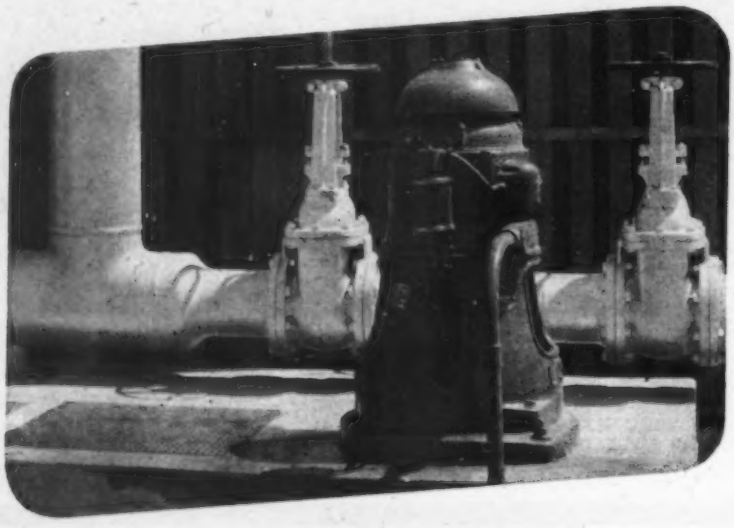
35—pH Meter

National Technical Laboratories, 820 Mission Street, South Pasadena, Calif., manufacturers of Beckman Instruments, recently announced a portable glass electrode pH Meter which "combines maximum accuracy and versatility with the convenience of full AC operation." Designated as the Beckman Model H Meter, the instrument can be plugged directly into any standard 110 v. 50|60 cycle AC line, and can be easily transported or installed permanently.

36—Pressure Regulator

An automatic pressure regulator, operating on the physical principle of the Cartesian Diver, a method new to industry, has recently been developed and manufactured by the Emil Greiner Company, 161 Sixth Avenue, New York. Entirely automatic, this industrial Cartesian Manostat, Model 5, requires no complex electrical or mechanical systems or extra equipment, and is completely self-contained, and will maintain constant pressure or vacuum to within 1/10 of 1 percent, the manufacturer claims. Bulletin ICM-96 is fully descriptive.





COOLING TOWER WATER

—OR WATER FOR ANY PETROLEUM NEED

Not how cheap but how good has always been the policy of the builders of Layne Well Water Systems.

For cooling tower—or use in any part of the petroleum processing or pumping industry, Layne Well Water Systems produce large quantities of water at an extra low cost.

These systems are scientifically engineered to have the rugged quality that assures extra long life and freedom from expensive upkeep cost. If you have a specific water producing problem, Layne engineers will gladly cooperate and offer logical and economical plans. No obligation.

Systems of any size—any capacity against any head. For further interesting details and facts, address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

LAYNE *Well Water Systems* VERTICAL TURBINE Pumps

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. * Layne Atlantic Co., Norfolk, Va. * Layne-Central Co., Memphis, Tenn. * Layne-Northern Co., Mishawaka, Ind. * Layne-Louisiana Co., Lake Charles, La. * Louisiana Well Co., Monroe, La. * Layne-New York Co., New York City * Layne-Northwest Co., Milwaukee, Wis. * Layne-Ohio Co., Columbus, Ohio * Layne-Pacific, Inc., Seattle, Washington * Layne-Texas Co., Houston Texas * Layne-Western Co., Kansas City, Mo. * Layne-Western Co. of Minnesota, Minneapolis, Minn. * International Water Supply Ltd., London, Ontario, Canada * Layne-Hispano Americana, S. A., Mexico, D. F.

37—Silicone Oils

DC 710 is a Dow Corning silicone oil developed especially for high temperature lubrication from 10° F. to 500° F. (—12° C. to 260°.). A variation of this silicone oil, DC 710G, provides excellent lubrication and protection for mechanisms continually exposed to heat, high humidity, or to weather. DC 710R, another variation, permanently lubricates such sealed-in precision devices as clocks and instruments. DC 710 can also be used as a high temperature bath liquid and as a high-temperature hydraulic fluid.

Detailed test results and physical properties of these silicone oils are contained in the new silicone notes preliminary data sheet A 20-1 with copies available from Dow Corning Corporation, Midland, Mich.

38—Cast-Steel Thermostatic Traps

Sarco Company, Inc., 475 Fifth Avenue, New York 17, is now making cast-steel thermostatic steam traps with patented helical bellows.

It is claimed that these new traps will:

a withstand the shock of external explosions, such as occur in oil refineries an chemical plants;

b handle corrosive condensate; and

c operate with pressures to 300 psi or with superheat.

The stainless steel thermostatic element resists corrosion and permits these traps to be used for superheat or for a maximum operating pressure to 300 psi. Another of this series has a bronze thermostatic element for maximum operating pressures to 225 psi saturated steam.

The thermostatic element is a patented helical bellows which permits an unusually large orifice.

39—Two-Cycle Gas Engine

Cooper-Bessemer Corporation, Mount Vernon, Ohio, has developed a new design in large two-cycle gas engines by which the manufacturers say, "users can take 10 percent more horsepower from this new engine than is possible from present engines of the same size and fuel consumption is reduced 15 percent under that of any two-cycle gas-burning engine ever built."

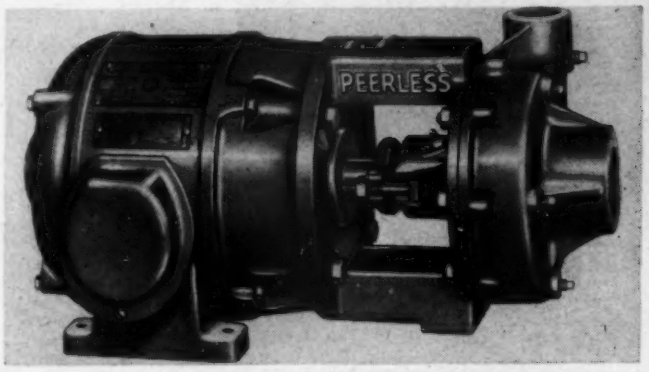
The engine, the "Turboflow," will be

in full production by the second quarter of 1948. It uses a combination of combustion principles worked out along the line of getting a greater volume of air and gas mixture into a more intimate relationship and then igniting it electrically at a greatly increased voltage through a standard spark plug.

A fuel consumption of 8500 Btu's per horsepower per hour is guaranteed.

40—Centrifugal Pump

A general utility centrifugal pump, with power drives from fractional to 20 h.p., has been introduced by Peerless Pump Division of Food Machinery Corporation. It is a single stage, end suction, vertically split case centrifugal pump, the Peerless Fluidyne, which is being manufactured in two types, both of which are capable of moving water and other liquids in capacities up to 1000 gpm against heads up to 270 feet. The Fluidyne type PE is an integrally coupled, compact electric unit in which pump and driving motor are anchored on the motor footing. The type PB is a belt driven unit with the iron frame and bearing mounts supporting the various pump sizes integrally cast.



Peerless Type PE Fluidyne Pump

41—Shut-Off Valve

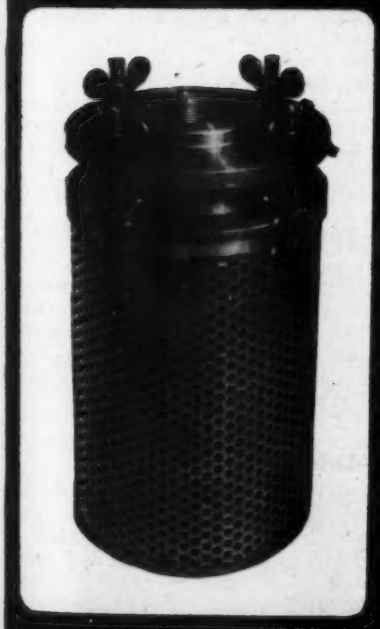
Quick-opening operation, leak-proof characteristics and heavy-duty, all-steel construction are features of a new shut-off valve being offered by Saval Company, 1915 East Fifty-First Street, Los Angeles 11. Designed for butane and other similar service, the unit is also available for water or corrosive service with a heavy cast bronze body. The valve employs Saval's patented "Shear-Seal" principle which provides a metal-to-metal seal that is self-aligning and automatically compensates for wear.

42—New Type Packing

A new type of packing, specially developed for the petroleum industry, has been announced by Quaker Rubber Corporation, Philadelphia. This packing, "Petro-pak" No. 1675, is said to be ideal for tight-sealing service on refinery and

For Reliable Performance...

FILTER UNITS by MULTI-METAL



Advanced design, in combination with improved materials and craftsmanship of the highest order, insures the superior performance of Multi-Metal Filter Units. Whether you require specially-fabricated or stock units, you will find that Multi-Metal is better equipped to serve you.

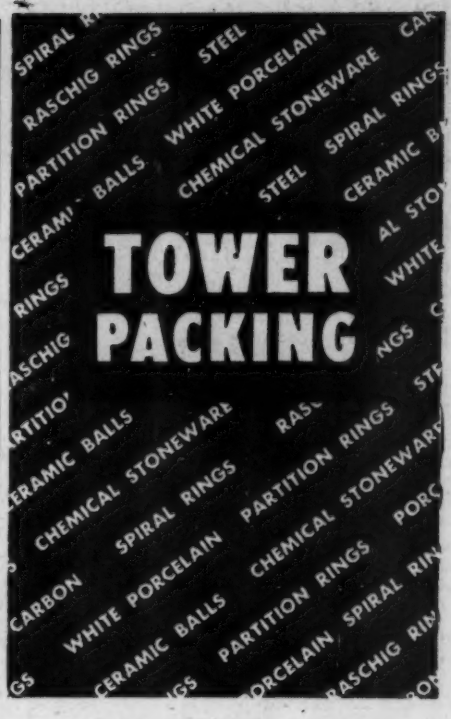
Multi-Metal's complete reconditioning service makes old filter units perform like new. Filter Leaves for standard equipment are stocked for immediate shipment. Special units can be made promptly to your exact specifications.

Always in stock — wire and filter cloth of all meshes, weaves, and metals. Order by the yard, piece, or roll.

Write for catalog and free wire cloth samples.

More than 35 years of service to process industries

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.



U. S. Stoneware offers a *full line* of Tower Packing: 15 different types and styles to meet virtually every tower packing requirement.

Raschig rings are offered in white porcelain, chemical stoneware, carbon or steel (subject to the availability of materials). Spiral rings, partition rings, and other styles are manufactured of tough, non-absorbing, well-vitrified chemical stoneware, guaranteed acid-and-corrosion proof.

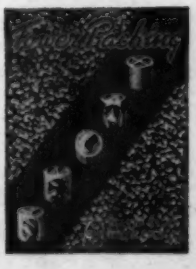
•

Have you a copy of

this FREE BOOK?

It Answers Questions Like These:

What's the percent of free gas space of a 1" Raschig ring? How many square feet of exposed absorption surface per cubic foot? What's the relative scrubbing capacity? How can we reduce resistance to gas flow?



Write for your free copy of Bulletin 51 PR Today!

U. S. STONEWARE
Akron 9, Ohio

ZALLEA Universal Expansion Joints

WHEN the refineries, power plants and chemical process plants needed a medium to absorb combined axial and lateral movements in high temperature lines, Zallea supplied the answer. The Zallea Universal Expansion Joint is capable of absorbing movement of the line in any direction—axially, laterally or angularly, or any combination of these.

Essentially, it consists of two corrugated elements linked together by a section of pipe. The amount of lateral movement that can be absorbed by a Zallea Universal Expansion Joint depends on the length of pipe between the corrugated elements. The expansion elements can be either of non-equalizing type for pressures up to 30 lbs. or self-equalizing for higher pressures.

Particularly suited for catalyst lines—since the joint offers no sharp crevices in which catalyst can pack—the Zallea Universal Expansion Joint has numerous applications in reactor risers and standpipes, regenerator standpipes, stripper and flue gas lines.

Zallea Universal Expansion Joints are specifically designed to fit the requirements of each individual application and can be designed for all temperatures and pressures. Send today for Catalog 47 containing complete information to: *Zallea Brothers & Johnson, 890 Locust Street, Wilmington 99, Del.*

Zallea
EXPANSION JOINTS

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS EXCLUSIVELY

field equipment handling oils, gasoline, and other volatiles at normal atmospheric temperature.

This product is made from a special rayon roving, developed mainly for mechanical packings and is saturated with a special lubricant that is said will not dissolve or wash out even when packing is subjected to the effects of oil, gasoline or similar solvents.

43—Pressure Control Pilot

A pressure control pilot for use with diaphragm regulating valves has been announced by Leslie Company, 167 Delafield Avenue, Lyndhurst, N. J. The control pilot is a mechanical device used to control the action of a diaphragm

regulating valve to maintain a constant controlled pressure.

Economical operation is claimed because there is no continuous leakage of operating pressure, particularly important for "stand-by" applications. The pilot is described as rugged and reliable, requiring no attention over long operating periods and no recalibration during service, and is made in nine controlled pressure ranges from ½ to 800 psi.

44—Tandem Combustion Unit

National Airoil Burner Company, Philadelphia 34, has issued Supplement 6 to Bulletin 50 describing the "National Airoil Airocool" tandem combustion unit for combined gaseous and oil fuels. Charts showing installations and a table giving capacity data are included.

45—Laboratory Supplies

The Fall issue of Eberbach & Son Company's (Ann Arbor, Mich.,) house magazine, the Eberbach "Announcer of Scientific Equipment," is off the press. Featured is an article entitled, "Functional Design of Laboratory Glassware." In addition, descriptions are included covering recent developments of laboratory apparatus and supplies.

46—Amberlite

"The Role of the Amberlites," ion exchange resins, in water treatment and

A STORY OF TWO ENGINEERS

●

Both have a Packing Problem!

Engineer Jones thought his packing problem was different . . . and knew it when his local packing supplier indicated not one but five separate installations to complete his job. His wry, troubled frown tells us he's looking for a simpler answer.

Engineer Smith knew his ABC's. No wonder he's smiling. One swift glance at his Palmetto Packing Selection chart solved his different packing job in a jiffy. Now he's free to tackle his bigger, more important duties.

●

MORAL: There is not *one* type of Palmetto Packing *for each* installation . . . There are only a *few types* of Palmetto Packings . . . and they *cover all applications*. Specify Palmetto . . . the Simple, yet Complete line. Write for your Palmetto A-B-C Packing Selection Chart today. It's simple as A-B-C.

TRADE MARK PALMETTO *Packings*

"There is a Palmetto Packing Distributor Near You."

GREENE, TWEED & CO.

NORTH WALES, PENNSYLVANIA

chemical processing, is the subject of a booklet prepared by the Resinous Products & Chemical Company, 221 W. Washington Square, Philadephia 5. Contributions made by the Amberlites in the transportation, chemical, canning, bottling, ice, paper, textile, dye and pigment industries are set forth and processes described.

47—Mass Spectrometer

A 20-page folder has been issued by Consolidated Engineering Corporation, 620 North Lake Avenue, Pasadena 4, Calif., describing the company's Model 21-102 mass spectrometer, and is available for distribution on request. The bulletin describes the use of the mass spectrometer in the analysis of complex mixtures, and is said to be so complete that it will answer most questions which may arise concerning the instrument and its uses.

48—Fractionation Assembly

A folder describing a precise fractionation assembly used by the National Bureau of Standards has been issued by The Emil Greiner Company, 161 Sixth Avenue, New York 13. The assembly, covered by U. S. Patent No. 2,387,479, is pictured and those interested are invited to write for article and reprint and Technical Bulletin 100 for more detailed information.

49—Lubricated Plug Valves

American Car and Foundry Company, 30 Church Street, New York 8, has revised its pamphlet on ACF lubricated plug valves and the new bulletin, now available, describes the full line in steel, semi-steel, bronze and other metals. Data include charts of specifications, photos of various items and sketches and cross-sections.

50—Power Stir

Eberlach & Son Company, Ann Arbor, Mich., gives a description of a new variable speed, high torque laboratory stirrer called "Power Stir," especially designed for functioning where a small, lightweight stirrer is needed. Complete description is offered.

51—Acetylene Generators, Manifolds

Air Reduction, 60 East 42nd Street, New York 17, has available a new 22-page catalog which lists and explains the complete line of Airco acetylene generators both stationary and portable. The catalog also shows Airco manifolds both oxygen and acetylene and gives information relating to National Carbide. Three pages are devoted to diagrams which illustrate typical manifold installations and show their flexibility and adaptability and two pages are devoted to gas control and safety devices for pipe lines such as station outlet valves and flashback arresters.

52—Small Boiler

A bulletin announced by the Babcock & Wilcox Company, 85 Liberty street, New York 6, describes the Type H Stirling boiler, a relatively small, water-tube unit, designed primarily for installation where headroom is limited. It

THE PEERLESS *Fluidyne*

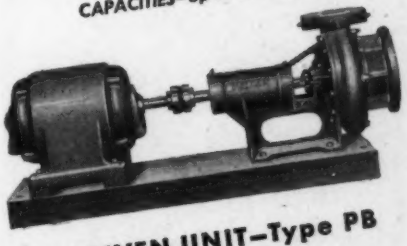
AN ECONOMICAL GENERAL UTILITY **CENTRIFUGAL PUMP**

PEERLESS PUMPS

ELECTRIC UNIT—Type PE

Sturdy, compact, close-coupled single stage design. Powered by standard stock NEMA motor. Highly efficient, versatile, durable; easy to install, operate and maintain. Utilizes small space. Versatile in use.

HEADS—Up to 270 feet.
DRIVES—Fractional to 20 H.P.
CAPACITIES—Up to 1000 g.p.m.



BELT DRIVEN UNIT—Type PB

Steel shaft, turning in grease lubricated ball bearings is built to receive either V or flat belt pulley; or may be direct-connected as shown to standard stock horizontal motor through flexible coupling.

THE FLUIDYNE MOVES WATER AND OTHER LIQUIDS WHERE YOU WANT THEM. The Peerless Fluidyne is ideally applied to a host of commercial and industrial uses. A natural for system pump sub-assemblies. Handles water as well as slightly viscous or alkaline liquids. Operates in any position.

FOR FULL DETAILS, REQUEST YOUR COPY OF BULLETIN NO. B-165.

PEERLESS PUMP DIVISION
Food Machinery Corporation

Factories: Indianapolis, Indiana; Quincy, Illinois; Los Angeles 31, California. District Offices: Chicago 40, 4554 North Broadway; Philadelphia Office: Suburban Square, Ardmore, Pa.; Atlanta Office: Rutland Bldg., Decatur, Ga.; Dallas 1, Texas; Fresno, California; Los Angeles 31, California.

high alloy tube supports for refineries

The reason we can consistently turn out sound chrome-iron and chrome-nickel castings is that we specialize in this work. All our metallurgical talents, our skilled foundrymen, our equipment and controls are geared to the exacting business of producing high alloy castings.

With a large modern foundry, we are in position to produce not only tube supports but any other casting, up to about 6 tons per casting (static) and up to about 15 feet in length and 24 ins. O.D. (centrifugal).

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is particularly suitable for industrial power plants, for process steam requirements, for small central stations and for heating purposes. The bulletin cites several typical installations and includes dimensional data for the various sizes and capacities of the unit.

53—Interchangeable Valves

Fisher Governor Company, Marshalltown, Ia., has issued Bulletin E-9 dealing with interchangeable inner valves. When Fisher reduced trim is used, it is pointed out, the valve port area may be changed by installing a new inner valve without changing the seat rings, thus making for practicability and flexibility.

54—Aprons and Sleeves

Industrial Products Company, 2820 North Fourth Street, Philadelphia 33, has issued a bulletin regarding its "Nitroflex" aprons and sleeves, a new line of protective apparel made of plastic material said protection against most acids, caustics, oils and solvents. Electronic sealing is used in order to avoid stitching and three weights are available.

55—Corrosion Resistance

Bulletin K, "Corrosion Resistant Materials and Equipment," has been released by U. S. Stoneware Company Akron, Ohio.

Selection of proper or suitable corrosion-resistant materials and equipment is discussed in some detail, many photographs, tables, etc., being used.

56—Surface Pyrometer

The Pyrometer Instrument Company, 103 Lafayette Street, New York 13, has catalog 160 on its pyrometer, provided with interchangeable extension arms and thermocouples. The instrument and its attachments make up a portable assembly for determination of any surface temperature determinations.

57—Water Conditioning

Liquid Conditioning Corporation, 114 East Price Street, Linden, New Jersey, has issued a leaflet, No. 10, on prevention of scale formation in cooling water. It outlines the different types of cooling system and the characteristics and requirements of each type and briefly presents for preventing scale deposition and elimination of corrosion.

58—Electronic Instruments

The Foxboro Company's Bulletin 397 describes "Dynalog" electronic instruments for the measurement and control of process variables. The "Dynalog" principle is set forth and various "Dynalog" circuits are shown in graphic form. Photos of the instruments also are included. Address Foxboro, Mass.

59—Nitrosyl Chloride

The Solvay Process Company, 40 Rector Street, New York 6, has announced a new booklet on Nitrosyl Chloride which will be of value to individuals or organizations interested or engaged in research. In addition to chemical and physical properties, this

booklet describes the new all nickel cylinders and fittings which have been developed for storing and shipping Nitrosyl Chloride, gives information on handling, laboratory preparation, safety measures and typical industrial applications. Also included are charts, sketches, a bibliography and patent references designed to assist technical and research men responsible for new chemical developments.

60—Testing and Measuring

General Electric Co., Apparatus Department, Schenectady 5, N. Y., has issued its "Specialized Testing and Measuring Equipment Catalogue" which gives information on some 100 modern equipments, many developed for GE and others developed at the request of other companies and since made available throughout the industry. A precise table of contents adds value to the volume.

61—Gaskets

Melrath Supply & Gasket Company, Inc., Philadelphia, has issued a new catalog illustrating gaskets and gasket materials, and covering all types of gasket service for industrial and scientific needs. Full specifications, sizes, useful engineering data and a simplified selector chart are included.

62—Centrifugal Pumps

Dean Brothers Pumps Inc., 319 West 10th Street, Indianapolis 7, has issued a new catalog (No. 200) describing its complete line of centrifugal pumps for industrial, chemical, petroleum and general service. The interchangeability, adaptability and modern designs that have been achieved by Dean Brothers pumps are featured. Many photographs, cross-sections, specification tables, etc., are included.

63—Heat Exchangers

The Duriron Company, Inc., Dayton 1, Ohio, has available an illustrated bulletin No. 1603, on heat exchangers for corrosive solutions. It deals with the high silicon iron from which the equipment is made, uses of the exchangers, advantages over other equipment, a sketch of a typical plating arrangement and a sketch of a typical anodizing installation. There is one drawing, showing a complete corrosion resisting unit, consisting of a heat exchanger, pumps, pipe and fittings, all mounted on a steel frame and assembled as a unit.

64—Pumps

American Manganese Steel Division of American Brake Shoe Company, Chicago Heights, Illinois, is distributing a bulletin, describing the Amsco-Nagle ball bearing type industrial pump. The bulletin is amply illustrated, one series of photographs showing a complete series of steps in assembling one of the pump units. Other photographs, diagrams and cross section views show features of manganese steel water-end parts, designed for resistance to impact, shock and abrasion.

65—Engineering Folder

Brown Engineering Company, Reading, Pennsylvania, has published a series of bulletins which are available in an attractive two-color paper cover. Products described in the standard-size folder are: Brown Ring-Oiling Bushings, No. 22; Jackson Time-Saving Vise, No. 23; Brown Buffer-Slot Couplings, No. 24; Mule-Pull Clutches, No. 25; Brown Sectional Stock Racks, No. 26; and Kanti-Lever Flexible Couplings, No. 28. Photographs, diagrams, specifications and general descriptions contained in these bulletins, in addition to illustrations showing actual applications, are accompanied by price lists where possible.

66—X-Ray Diffraction

A folder on X-ray diffraction is available from North American Philips Company, Inc., 100 East 42nd Street, New York 17. Titled "X-ray Diffraction Camera for Microtechniques," it shows construction and explains application of the new camera which is especially adapted to fiber analysis.

67—Synthetic Chemicals

Carbide & Carbon Chemicals Corporation, 30 East Forty-second Street, New York 17, has issued a revised edition of the booklet, "Physical Properties of Synthetic Organic Chemicals." The 12-page volume has been arranged as a condensed guide for users of organic chemicals.

It contains data on applications and

LENAPE MANWAYS and FITTINGS

SIMPLE • ECONOMICAL

Externally removable manhead support.

Lenape elliptical access openings (straight rings or flued and curved saddles) and fittings, of the pressure loaded or "self-energized" type are produced in sizes ranging from 4" x 6" to 18" x 24".

Swing support gear, to carry cover inwardly or outwardly of the pressure vessel, as illustrated at the left, is particularly convenient where frequent access is necessary. Various other types are available.

Ring and fittings assembly for tank construction.

Write today for our Bulletin 4-61 and current price schedule S-47 — feel free to call upon our engineering department to discuss design and fabrication problems with you.

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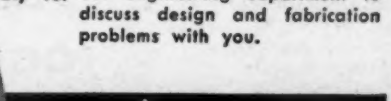

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Dept. 106 West Chester, Pa.
RED MAN PRODUCTS

Hi-Pressure Gage Glasses

Round, Tubular and Flat Type

RUBBER GAGE GLASS GASKETS
Series 750 . . . All Sizes

Fig. 21 Fig. 22

Other Ernst Specialties
are given in Catalog No. 48 P

GAGE GLASS ILLUMINATORS
NEW PLASTIC GUARDS
SIGHT FLOW INDICATORS
SPLIT-GLAND WATER GAGE
STEEL GAGE VALVES
FLAT GLASS INSERTS
ALL IRON GAGES
HIGH & LOW ALARM COLUMNS
MICA SHIELDS AND GASKETS
AND OTHER HELPFUL TIPS ON
BOILER ROOM SAFETY

Inclined for Better Visibility
Standard Type—Offset Adjustable Inclined Gage Fittings

Fig. 12

Fig. 4-P

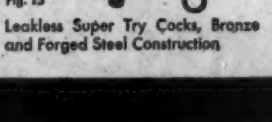
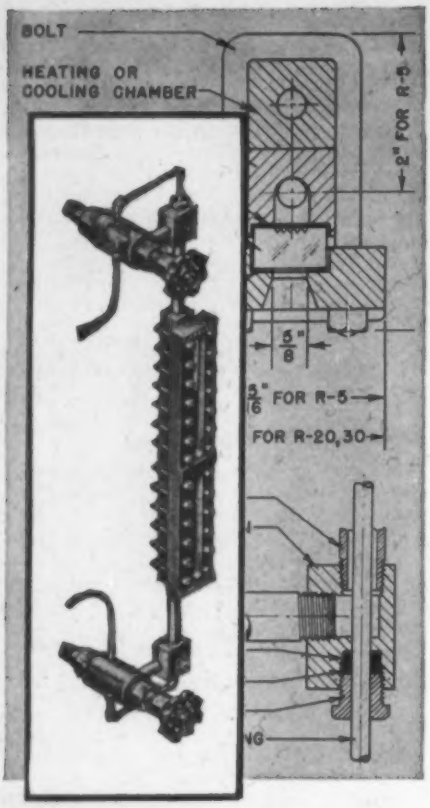


Fig. 13

Leakless Super Try Cocks, Bronze and Forged Steel Construction

Send for Catalog 48P

Ernst WATER COLUMN & GAGE CO.
LIVINGSTON, N. J. LIVINGSTON 6-1400



JERGUSON HEATED AND COOLED GAGES

Give Accurate Readings Under All Conditions

USE Jerguson Heated Gages for accuracy if you are dealing with high viscosity liquids that flow sluggishly.

On the other hand, if you are dealing with highly volatile liquids which tend to boil, use Jerguson Cooled Gages with circulating cooling medium.

In either case, Jerguson engineers have the answer, with a complete line of gages that give accurate reading of *all* liquids under *all* temperature conditions.

Jerguson Heated-Cooled Gages are made in internal tube and double chamber models for all pressures.

Illustration shows Internal Tube Model, Reflex Type, with No. 93 Valves. Write for Data Unit No. 17.

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Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

physical properties of more than 175 synthetic organic chemicals. The material is presented in tabular form for easy reference.

Copies of the booklet may be had by using the card in this section of Petroleum Refiner or by writing to the corporation and asking for Form 6136.

68—Differential and Air-Operated Controllers

The Brown Instrument Company, a division of Minneapolis-Honeywell Regulator Company, Wayne and Roberts Avenues, Philadelphia 44, has announced two new catalogues as follows: No. 2221 "Differential Controllers for Flow and Liquid Level" and No. 8905 "Air Operated Controllers."

Schematic diagrams, photographs and dimensional drawings illustrating the constructional features and principles of operations are shown for all instruments described, the former giving information "on suitable instruments and systems that alone or in combination will answer the simplest or most involved control problem" and the latter containing "valuable information on instruments for the automatic control of industrial processes."

69—Laminated Plastics

A 64-page booklet on laminated plastics, just published by the Plastics Division of General Electric Company, Pittsfield, Mass., contains complete information on the manufacture, application engineering and properties of all types of Textolite laminated applications. It lists 44 different grades of the sheet material along with their electrical, physical and mechanical properties.

Other sections of the booklet contain all necessary information on these tubes and rods, bearing materials, silent gears, decorative surfaces, translucent sheets, name-plates, molded-laminated plastics, low-pressure laminated plastics, methods and fabricating laminates and ordering instructions.

70—Water Purifiers

Liquid Conditioning Corporation, 114 East Price Street, Linden, N. J., has devoted its Bulletin No. 7 to a description of effective methods of removing iron, manganese and silica from water supply. It explains the modern processes and types of equipment for the purpose, being illustrated by diagrammatic drawings showing principles of design. Bulletin 6 is devoted to iron and manganese removal and No. 7 to silica removal.

71—Temper Designations

"Alcoa Temper Designations for Cast and Wrought Products" is the title of a pamphlet issued by Aluminum Company of America, Pittsburgh 19, Pa. Metallurgical advances and recent im-

HIGH-VOLATILE LIQUID STORAGE NEEDS *DEPENDABLE* FIRE PROTECTION

Blaw-Knox Aquatomic Fog Nozzles have four features that assure dependable protection:

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Blaw-Knox offers Standard Wet and Dry Pipe Systems, as well as Thermostatically Controlled Pre-Action and Deluge Systems.

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SPRINKLER DIVISION
832 Beaver Ave., N.S., Pittsburgh 12, Penna.

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

proved fabricating techniques showed the company that its present temper designation system for aluminum and aluminum alloys was inadequate and these are met in the new plan which will be effective on all shipments commencing January 1, 1948. The revised system also "will provide a definite pattern for future developments."

72—Depth Gauge Tables

Wm. Fogle, Publisher, 2412 N. Beachwood Dr., Los Angeles, California, has Book No. 5—Fogles Depth Gauge Tables For Tanks With Flat Heads, ready for distribution. The book contains the volume in U. S. gallons for each inch of depth for the entire tank and for each inch and foot of length, or horizontal cylindrical storage tanks with flat ends for the storage of gasoline, oils, or other liquids. Tank diameters covered range from 12 to 144 inches and lengths from 2 to 40 feet. Price $5.00 per copy, postpaid and insured.

73—Meter

Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, has issued Bulletin 233, for presenting details of its electronically operated area meter, for measuring liquids commonly found in refinery processing. It explains applications sizes and pressure standards. Both photographs and sketches are used to illustrate the two types of transmitters.

Bulletin 231 on Bailey electronic instruments, explains the operation of impedance bridge measuring circuits as used in the area meter.

74—Steam Traps

Rockwell steam trap, for pressures up to 150-300 psi are described in Bulletin 428, W. S. Rockwell Company, 200 Eliot Street, Fairfield Conn. This steam trap, designed for industrial process heating operations, features continuous drain, positive slide valve seal, no steam loss, no priming, no leakage, no hammer, chatter, or noise. It is recommended where uniform, accurately controlled temperatures and pressure of dry steam in equipment and in processes are necessary. Copies will be sent on request.

75—Screw Pumps

A revised catalog has been published by Sier-Bath Gear and Pump Company, North Bergen, N. J. Description and uses of Sier-Bath internal and external type screw pumps and other data are given.

76—Expansion Joints

A 60-page bulletin offers a comprehensive catalog on expansion joints and connectors. In pictures, text and diagrams, it describes various types of expansion joints, together with manufacturing processes. The catalog, which also includes 20 double pages of specific reference data on the many joints, is No. 47 and is available from Zallea Brothers and Johnson, 814 Locust Street, Wilmington 99, Del.

77—Welding Fittings

Tri-Clover Machine Company, Kenosha, Wisconsin, has prepared a complete catalog on its Zephyrweld welding fittings. Specifications of the several standard products that make up the line are given along with an outline of the industries and services into which the equipment can be adapted.

78—Smoke Indicator

Bulletin 580-C, just issued by Ess Instrument Company, 96 S. Washington Avenue, Bergenfield, N. J., describes a new model smoke indicator brought out primarily for use with oil and stoker-fire equipment that requires a bell alarm to notify the operator when he has reached a point that violates most city smoke ordinances. A plan for installation is included in the bulletin.

79—Steam Cleaning Unit

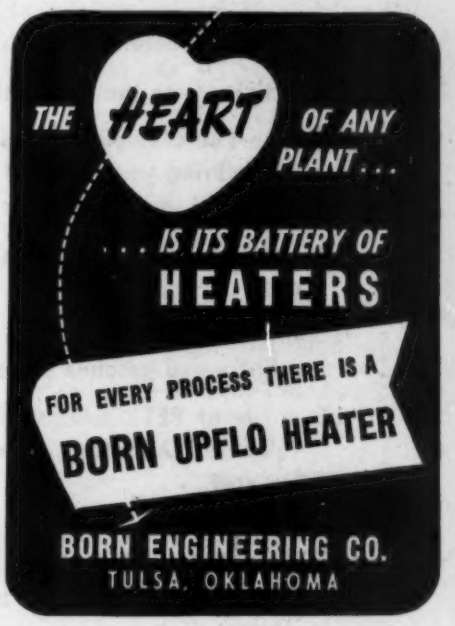
Bulletin 6327R, issued by Oakite Products, Inc., 22 Thames Street, New York 6, describes the new Oakite-Vapor steam cleaning unit, available in three models, basic (stationary), portable (for shop use) and trailer chassis model. Data on unit construction, engineering specifications, job applications, etc., are included.

80—Oil Test Set

Roberts-Konrad, Inc., 90 West Street, New York 6, has issued a folder on its new Rakon oil test set, which is a compact field kit of equipment for determining flash point, viscosity and gravity of oils.

81—Welding Fittings

Bulletin 47-1, just issued by Midwest Piping & Supply Company, Inc., 1450 South Second Street, St. Louis 4, Mo.,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...IS ITS BATTERY OF HEATERS
FOR EVERY PROCESS THERE IS A
BORN UPFLO HEATER
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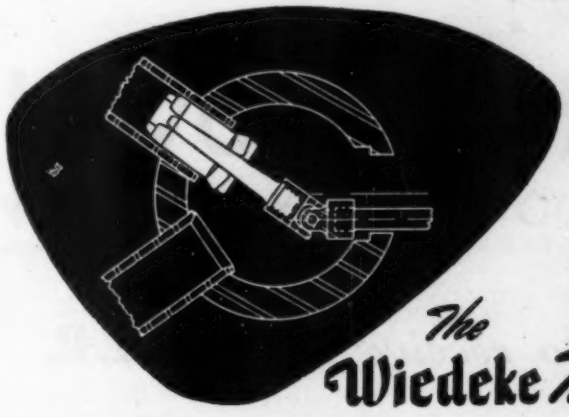

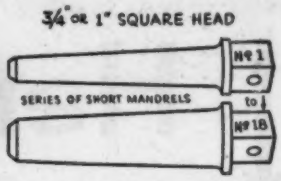

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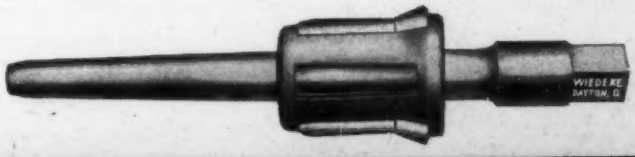
The mandrels and rolls are made of controlled-quality Alloy Tool Steel, carefully selected and heat treated . . . for dependable service.

For complete details, see your dealer, or write today for IDEAL Bulletin No. 65-B.



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☐ Manufacturer
☐ Supply Company
☐ _____

Return to P. O. Box 2608, Houston 1, Texas

lists stainless steel welding fittings now available. It includes not only the usual type catalogue information, but also suggestions for the welding of stainless steels. Interesting photographs of fabricated piping and stainless steel pipe coils also are included.

82—Valve Bulletin

"Pneumatic Control Valves and Controller Accessories," Bulletin 277-2 of The Foxboro Company, Foxboro, Mass., has just been issued in a new edition. Featured are a color page showing the various identifying enamel finishes offered on "Stabilflo" Valves; and plates and tables of specifications for control valves, needle type valves, etc.; and information for computing of valve sizes.

83—Fork Lift Truck

Selection of the correct fork lift truck, industrial tractor, or fork lift truck accessory, for any materials handling job are discussed in a new 28-page Lift Truck Guide by Towmotor Corporation, 1226 East 152nd Street, Cleveland 10, Ohio.

The pocket size booklet contains illustrations and drawings of the complete line of Towmotor materials handling equipment, together with a list of important specifications for each model.

84—"Electronic Scriber"

Bulletin C2 has been released by the Wheelco Instruments Company, 847 W. Harrison Street, Chicago 7, in which design, operating and specification data pertaining to the new Wheelco Capacilog, "an electronic scriber" are shown. Measuring, indicating, recording and controlling functions are fully explained with principal components illustrated and defined.

85—Strainer

"Self-Cleaning Strainers for Steam, Air, Gas or Liquid Service" is the title of Bulletin 465, just issued by Leslie Company, 169 Delafield Avenue, Lyndhurst, N. J. Several typical strainer installations for protection of regulators, regulating valves, stop valves, traps and process equipment, as well as the application of strainers to drain steam, air and gas lines are described and tables show screen specifications and total free hole areas which facilitate selection of correct screen for different services.

86—Oil Burner

The Babcock & Wilcox Company, 85 Liberty Street, New York 6, has issued a bulletin which gives details on its new wide range of Y-jet steam atomizing oil burner. The burner was designed for both stationary and marine installations, to serve a range of boiler ratings without changing the number of burners or the sizes of sprayer plates.

87—Chemical Schedule

Interim price schedule, No. 4, has been issued by J. T. Baker Chemical Company, Phillipsburg, N. J. It lists all fine and industrial prices and information re-

garding the company's products. Featured is an announcement that Charles H. Slater, for several years head of the fine chemical division, has been promoted to assistant general sales manager.

88—Oil Burners

Peabody Engineering Corporation's (580 Fifth Avenue, New York) Bulletins 803 and 903 respectively describe the operation of heavy-duty mechanical and steam-atomizing oil burners and combined gas and oil burners for industrial boilers, heaters and furnaces as well as central station installation. Automatic fuel oil pump and heater sets also are shown.

89—Hydrogenation

A booklet on hydrogenation has been published by Hooker Electrochemical Company, Niagara Falls, N. Y. This Bulletin No. 8, discusses the research and developmental work that Hooker is prepared to do, the facilities for both high-pressure and low-pressure hydrogenation, the types of hydrogenation reactions, etc.

90—Flow Measurement

A 32-page bulletin, "A New Era in Liquid & Gas Flow Measurement," is profusely illustrated and describes the numerous advantages of the "Flowrator" meter (formerly called "Rotameter") for flow rate measurement. Address Fischer & Porter Company, Department 1C-F, Hatboro, Pennsylvania.

91—Flowmeter

Bulletin 905, Commercial Research Laboratories, Inc., 20 Bartlett Ave., Detroit 3, Mich., describes that company's Type 8 flowmeter, termed "the new standard in the industrial flowmeter field." Photographs and schematic drawings are included in the folder which sets forth full performance and design specifications.

92—High Temperature Valves

Kerotest stainless and alloy steel valves for chemical industrial processing and refinery services are described in Booklet 47-AS, which also includes a specification guide for valve buyers. Address Kerotest Manufacturing Company, 2525 Liberty Avenue, Pittsburgh, Pa.

93—Vertical Type Engine

Troy Engine and Machine Company, Troy, Pennsylvania, has issued Bulletin 306, which describes the Troy-Engberg steam engine. Sectional drawings, engineering data and construction details are presented and generating sets are discussed.

94—Welding Fittings

A folder describing the fabrication of Robinson light wall stainless steel fittings has been released by John B. Astell & Company, Inc., 90 West Broadway, New York 7. A photograph of each type of fitting and a chart of standard sizes are included.

95—Conical End Fittings

Tri-Clover Machine Company, Kenosha, Wis., announces an entirely new catalog (No. 847) covering their complete line of stainless steel flanged-type conical end fittings. Concise data on physical characteristics, fabrication, and adaptability, etc., are included.

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

96—Steam Separation

A bulletin, "Steam Separation," released by The Babcock & Wilcox Company, 85 Liberty Street, New York 6, describes B & W's equipment for steam separation in boiler drums, steam scrubbers and cyclone steam separators. Operation of the equipment is shown, together with illustrations of applications in several types of boiler units.

97—Rubber Footwear

A new catalog section (12040) on its line of industrial rubber footwear published by The B. F. Goodrich Company, Akron, Ohio, is available upon request. Boots, rubbers, gaiters, work shoes and pacs are described.

98—Interchangeability

Bulletin 468 titled "Interchangeability" which discusses the four important phases of interchangeability as applied to a well integrated line of regulators, has been issued by Leslie Company, Lyndhurst, New Jersey. Listed in table form are key internal working parts of regulators which are renewable and interchangeable in various sizes of Leslie regulators serving different functions.

99—Reflectogage

The operation and applications of the Sperry Reflectogage, for thickness measurement and the inspection of bond, are completely described in Technical Data Sheet 3700, a publication of Sperry Products, Inc., 1505 Willow Avenue, Hoboken, N. J.

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for production line method of PICKLING, and the application of AMERCOAT Vinyl Baked Phenolic linings in DRILL PIPE, SALT WATER and CONDENSATE PIPE.

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Texas University-API Plans Refinery Survey

The University of Texas on November 1 launched a nationwide survey of organized training practices employed in petroleum refineries as a research of the American Petroleum Institute. An API committee will work with the University in making the survey which will reach every U. S. refinery with normal capacity of 5000 barrels daily or more crude intake, James R. D. Eddy, industrial and business extension training bureau director, said.

Objectives are six: 1) To furnish refinery management with training practices data for purposes of comparison; 2) to indicate overall trends in training practices; 3) to furnish educational agencies with a guide whereby their programs may be more closely coordinated with industry requirements; 4) to supply guidance to the API committee in the formulation of its program of assistance to the industry; 5) to suggest to training staffs or refineries possible improvements in training programs, and 6) to indicate to management some possibilities of in-service training to increase efficiency.

GE Educational Fund

Aid to college and university graduates who wish to undertake or continue research work in scientific and industrial fields has been announced by General Electric Company for the 24th consecutive year.

Applications now are being accepted for the scholastic year 1948-1949 for grants under the $1 million GE educational fund, from the income of which the fellowships are awarded, according to W. W. Trench, company secretary and chairman of the education committee.

New Gulf Oil

Combining full detergency and the tough film qualities of paraffin base, a new oil for automotive diesel engines and for gasoline engines operating in extra heavy duty service has been developed by Gulf Oil Corporation.

The new product, "Gulflube H. D. Motor Oil," will incorporate the most important recent advances in lubricant research in a form specifically adapted to its field of service, according to the manufacturer.

The full detergent characteristic of the oil, in automotive diesel use, "assures cleaner engines, avoiding high temperature sludge, piston varnish, lacquer, and stuck rings." The oil has also been made entirely non-corrosive.

SCMA Program

The November 20 meeting of the Southern California Meter Association will feature a paper on "Fuel and Steam Economy" by Merrill Berkley, Berkley Engineering and Equipment Company, who will discuss the application of various instruments and controls used in effecting fuel savings and in reducing steam waste in the average industrial plant.

Preston W. Hill, Signal Oil and Gas Company, will give a talk on a subject in the category of SCMA's "Bugs on Parade" feature.

About

EQUIPMENT—SERVICE

Suppliers

Quaker Oats Department Appoints William Webster

The Chemicals Department of the Quaker Oats Company has named William A. Webster to take charge of nation-wide sales of furfural residue. His headquarters will be Board of Trade Building, Chicago. For 13 years Webster was divisional sales manager with Chilean Nitrate Sales Corporation and for six years with American Potash and Chemical Corporation in a similar capacity.

Webster

Oilwell Supply Gives Awards To Its Long-Time Employes

Seventy-two employes of Oil Well Supply Company, a U. S. Steel subsidiary, were awarded service emblems in Dallas last month for employment ranging from 15 to 46 years. John Byers Rice was the oldest in point of service to receive a gold emblem, having begun his employ in the company in 1901.

President Fred F. Murray told the group that constant effort would be required in the future on development of new designs, and improvement of products to meet changing conditions.

Oilwell's new program to honor employes with 15 or more years service was inaugurated September 20, at Oil City, Pa., when Murray presented service awards to 349 employes, 263 from Imperial Works at Oil City, and 86 from the Wilson-Snyder Division at Braddock, Pa.

Celanese Appoints Three to New District Sales Posts

Celanese Chemical Corporation, division of Celanese Corporation of America, has extended its area sales representation to Los Angeles, Detroit and New England. Chemical production in the company's Chemcl plant near Bishop, Texas, has reached new highs, it was explained as a basis for the move.

John Stevens has been assigned to the New England area with headquarters temporarily in New York City; C. Harry Snell will be sales representative on the West Coast, Los Angeles; and Thomas J. O'Dwyer will work out of Detroit for the Midwest area.

Petroleum Additives Man Is Announced by Du Pont

E. Hearn Simpson has been named by the Du Pont company to the newly created position of assistant sales manager of petroleum additives. Barry V. Cornwall will succeed him as sales manager for the alcohol and camphor section.

Simpson's appointment is the result of expanding activities of Du Pont's Petroleum Chemicals Division for the direct sale of tetraethyl lead to the refining industry, it was explained. Du Pont will start marketing its own anti-knock compounds on January 1, 1948.

Simpson, 38, has been with Du Pont since 1930 and for five years his experience included selling petroleum antioxidants to the refining industry.

Plastic Applicators Expands Its Facilities at Houston

Plastic Applicators, Inc., 9110 Katy Road, (Box 7631), Houston, recently completed an expansion program which permits application of their plastic coating to the interior of pipe up to 32 feet in length. The coating used is NuLine, a phenolic resin, and it is being applied to various types of equipment including plug cocks to eliminate sticking in acid service. Coated valves are being used very successfully in sulphuric acid alkylation units in several of the leading refineries of the Gulf Coast.

The company's service includes lining process lines, tanks, valves, fittings, and other types of equipment subject to corrosion or contamination. This plastic is said to be highly resistant to most acids including sulphuric, hydrochloric, acetic, phosphoric and sulphurous. It is unaffected by hydrogen sulphide, sea water, hydrocarbons, and most solvents.

Officers of the company are G. J. Duesterberg, president, H. M. Kellogg, vice president, and J. W. Kellogg, secretary and treasurer.

International Goodrich Names Reed Representative

John Reed III has been assigned as special representative in the Caribbean area by International B. F. Goodrich Company, a division of The B. F. Goodrich Company, Akron, Ohio. Reed's area will include Venezuela, Netherlands West Indies and the Guianas, with temporary headquarters at the Queens Park Hotel, Port of Spain, Trinidad. He will handle, among other items, industrial rubber products.

Reed

Reed resigned from the Navy early in 1947. He served one tour of duty with the Navy as assistant area petroleum officer in the Trinidad sector.

Merz' Anniversary

On October 12, 1947, August Merz completed 50 years of service with American Cyanamid Company and its affiliates.

In 1897, Merz started his career with the company when he joined Heller and Merz, a partnership formed in the late 60's by his father and his uncle, the first to manufacture ultramarine blue in

Simplified Maintenance of Pumping Station Floors

FLOOR CLEANING the Oakite way adds up to safe footing because specialized Oakite floor-cleaning compounds leave no slippery soap film. And they do a good job of removing heavy grease deposits. They may be used with complete safety on all types of floors . . . cement, wood, tile, etc.

Oakite Penetrant One of the Best!

One of Oakite's best all-round floor cleaning compounds is Oakite Penetrant. This material does an extremely efficient job of removing caked-on grease, oil and dirt. It's a fast cleaner. Saves a lot of hard scrubbing. Has a pleasing pine odor. Ideal for cleaning pumping station floors, garage floors and the like. It's extremely economical.

Send for Fact Filled Booklet

12-page booklet gives all the interesting facts about Oakite Penetrant. Tells how, when and where to use this multi-purpose detergent. Send for a free copy today. See it in action. Ask for on-the-spot workout. No obligation.

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this country. In 1929, Heller & Merz was purchased by American Cyanamid Company and when in 1930 operation was assumed by Calco, Merz was made a vice president of Calco.

Cooper-Bessemer Announces Gehres and Boyer Promotion

The Cooper-Bessemer Corporation of Mount Vernon, Ohio, and Grove City, Pa., last month announced that H. A. Gehres had been named executive vice president and that Ralph L. Boyer would become vice president and chief engineer.

Both Gehres and Boyer have achieved

Gehres

Boyer

positions of leadership in the diesel, gas engine and compressor fields during their long Cooper-Bessemer association, B. B. Williams, chairman of the board, declared. Gehres started with the company in 1910 when it was known as the C. & G. Cooper Company, whereas Boyer joined Cooper-Bessemer in 1926 as diesel engineer.

Lukens Open House Visitors See Process of Steelmaking

"A Visit to Lukens" is the title of a brochure recently issued by Lukens Steel Company, By-Products Steel Corporation and Lukenweld, Inc., all of Coatesville, Pa., and distributed to several hundred visitors who recently came from all parts of the country to be the companies' open house guests.

The plants, which include the world's largest plate mill, are pictured in an attractive manner and all of the departments which were shown the visitors are included in some detail. Open house visitors were particularly impressed with the clad steels department where is carried on a process by which a light layer of clad material—nickel, stainless steel, Inconel or Monel—is bonded uniformly and permanently to a backing plate of mild steel.

Concluding articles in the brochure are "The Economics of Steelmaking" and a list of Lukens products and their applications illustrated with pen and ink sketches.

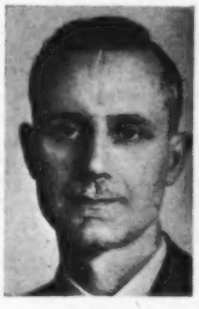
Refractories Division of Babcock & Wilcox Meeting

A sales meeting of the Refractories Division of the Babcock & Wilcox Company was held October 10-13 in Augusta, Ga., where the company's refractories plant is located.

The meeting's program included presentation and discussion of papers dealing with the manufacture of refractories, sales problems, and applications of the division's products which include refractory firebrick, insulating firebrick and refractory mortars, plastics and castables. An inspection of the plant and a visit to the kaolin mine also were on the schedule.

Kinkade Delivers Address in Oklahoma on Heat Transfer

H. J. Kinkade, sales manager, oil field and heavy industrial units, Young Radiator Company, of Racine, Wis., spoke on "Heat Transfer" recently at Bartlesville, Oklahoma. He stressed the fact that "the area of heat transfer surface is a large factor in the cost of heat transfer equipment" and, therefore, it should be "kept at a practical minimum."



Kinkade

Listed by the speaker were the following factors affecting over-all heat transfer from a fluid inside tubes to another fluid outside the tubes: 1) Mean effective temperature difference between the two fluids. 2) Amount of interior surface. 3) Amount of exterior surface. 4) Material of tubes. 5) Thickness of tubes. 6) Film factor inside tubes. 7) Film factor outside tubes.

The reliable way to determine overall heat transfer efficiency is by actual tests of the particular surface to be used under the actual conditions of use, Kinkade declared.

Esch-Condit, Inc., Is New Name of Houston Company

Frank M. Esch Company announced last month its incorporation under the name of Esch-Condit, Inc., with offices at 108 Portwood, Houston 11. This company will have Frank M. Esch as president and treasurer, Paul A. Condit, vice president; Robert B. Miller, secretary; and Jim W. Muster, assistant secretary and treasurer.

The company is exclusive representative for a number of manufacturers, their lines including valves, automatic controls, steam specialties, chemical pumps, cooling towers, heat transfer equipment, gauges, etc.

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and
HEAT EXCHANGERS

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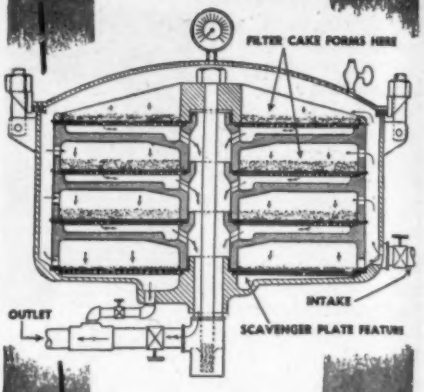

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- Patented Scavenger Plate permits complete batch filtration. (It's virtually an auxiliary filter with an independent control valve.)
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. . . why?

Because filter media are supported on a horizontal plane and filter aids floated into position uniformly, filtration takes place uniformly over entire filtering areas. Flow through filter is always *with* gravity. Sparkler Filtration Is *Engineered* Filtration—we invite correspondence on your problem. You will receive the advice of filtration scientists with a quarter of a century of experience in a specific field.

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MUNDELEIN, ILLINOIS

New Officers for Attapulgus

Attapulgus Clay Company and Porocel Corporation announce removal of their executive, sales and general offices from 260 South Broad Street, Philadelphia, to 210 West Washington Square, Philadelphia 5.

"Fire Stop" to Dealers

First trailer truck caravans of an exclusive, patented fire-resistant paint called "Fire Stop," manufactured by Plicote, Inc. (Warren Standard Company), Pittsburgh, have been sent to distributors all over the U. S.

A wall covered with "Fire Stop" merely formed brown blisters when exposed to the flame of a Bunsen burner at 3000° F. for one full minute and flames extinguished themselves, the company claims.

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Vapor Recovery Systems To Reopen Tulsa Office

Vapor Recovery Systems Company reopened its Tulsa office at 533 Mayo Building on November 1 with W. H.

Worsham

Scotty

Worsham, Jr. in charge of sales engineering.

Originally from Houston, Worsham holds a B.S.Ch.E from Rice Institute.

Angelo D. Scotty, Jr. has been appointed sales engineer for the company in Houston where he will assist John L. Shaunty. Scotty is a graduate of Rice Institute, where he obtained a degree of B.S.Ch.E.

Four New Representatives Are Appointed by McAlear

McAlear Manufacturing Company, 1901 S. Western Avenue, Chicago, manufacturer of valves, regulators and controllers, has announced the recent appointment of four new representatives as follows: Howell Engineers, 2501 Travis Street, Houston 1; Joe P. Dillard, Camp and Griffin streets, Dallas 2; Laney Company, Kennedy Building, Tulsa 3; and Paramount Manufacturing Company, 900 Mills Building, San Francisco (with a branch at Los Angeles).

William Ludvik is president of McAlear.

Aerofoam Tested

Oil refinery officials, aviation authorities and Philadelphia fire department officers last month saw an intense benzol fire brought under control in 40 seconds by wartime-developed fire extinguishing foam. The test was conducted at Northeast Airport, Philadelphia, by National Foam System, Ins., which used the company's Navy-designated "bean soup" aerofoam in the test.

Johnson With Aloyco

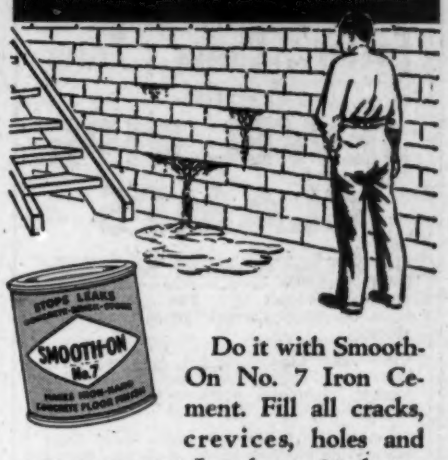
H. E. Johnson has been appointed Chicago district manager by Alloy Steel Products Company, Linden, N. J. His headquarters will be at the new sales office 332 South Michigan Avenue. Johnson was previously with Edward Valves, Inc., as sales engineer in the Chicago area and earlier was with The Crane Company in Chicago and Philadelphia.

Timken Roller Changes

H. C. Edwards, chief engineer of research and development, has been appointed director of research and development to succeed J. F. Leahy, 65, who retired October 1, after forty-five years of service with The Timken Roller Bearing Company, Canton, Ohio.

Walter F. Green, assistant manager of research and development, will become manager of research and development.

STOP LEAKS
In Concrete, Brick or Stone
BASEMENT WALLS and FLOORS



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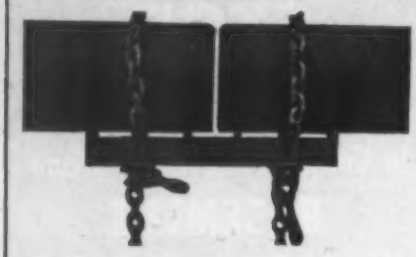

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115 FULTON STREET
NEW YORK 7, N.Y.

Assistant Managers Are Appointed by Worthington

Edwin A. Murray and Howard M. Boteler have been appointed assistant managers of Worthington Pump & Machinery Corporation's compressor division at Buffalo, N. Y. Murray is in charge of industrial and government compressor business; Boteler, in charge of oil refinery and chemical compressor business.

For the past 14 years Boteler has been associated with the compressor division while Murray, before joining Worthington in 1935, was associated for five years with General Electric.

G-E Promotes Linder, Wiles and Arthur Treece

C. H. Linder has been appointed assistant manager of manufacturing for the General Electric Company's Apparatus Department. Linder, assistant manager of the Schenectady works since 1943, is a 1927 graduate of the University of Texas where he received an M.S. degree in electrical engineering.

Addison E. Wiles, assistant manufacturing manager of GE's Plastics Division, has been named manager of the Pittsfield Molded Products Works, Wiles succeeds Arthur C. Treece who has been named assistant manager of the new GE plastics laminating plant at Coshocton, Ohio.

Sommer to Jefferson

Nolan B. Sommer has recently joined the sales department of Jefferson Chemical Company, Inc., as market development representative. Dr. Sommer was previously a research chemist in the Stamford laboratories of the American Cyanamid Company.

Dr. Long Promoted

Calco Chemical Division, American Cyanamid Company, has announced the appointment of Dr. Robert S. Long as an assistant director of the organic section of the research department. Dr. Long joined Calco in 1940 and since 1944 has served as an assistant chief chemist of the organic section.

Denver Representative

International Nickel Company has appointed Metal Goods Corporation, 817 Seventeenth Street, Denver 1, Colo., as distributor of primary nickel for alloying purposes and mill forms of Monel, nickel, and Inconel, in Colorado, Wyoming and New Mexico.

New Chief Tool Engineer

Francis A. Paquin has been appointed chief tool engineer of Sier-Bath Gear and Pump Company, Inc. of North Bergen, N. J. Paquin was formerly chief tool designer for Wright Aeronautical Corporation and, before that, was with Brown and Sharpe Manufacturing Company.

Milton Routh Joins Foxboro

Milton E. Routh has been named manager of the Shreveport, La., office territory of The Foxboro Company, succeeding E. A. Thomas, resigned. Since completing his educational training Routh has been continuously engaged in instrument engineering with two of the leading oil refining companies.

Chiksan Appoints Two

Two new appointments within the Chiksan organization have just been announced by L. J. Laird, vice president in charge.

Robert Jones has been assigned to

Myers

Jones

Chiksan Company's New York office as sales engineer in the New York territory where he joins E. T. Landgraff, manager, and R. W. Sexton, Jr. He has been a member of Chiksan's engineering staff for the past several years.

L. C. Myers has been assigned by Chiksan to the Rocky Mountain area, headquarters in Denver. Myers has been with Chiksan since 1944 and heretofore handled field service in California.

Babcock & Wilcox Tube Names Foglesong to Detroit Post

Babcock & Wilcox Tube Company has appointed Frederick H. Foglesong to the staff of its Detroit district sales office. Prior to this connection with B&W Tube Company, Foglesong was with the Steel & Tube Division of the Timken Roller Bearing Company in its Detroit office. He is a graduate of Michigan State College and a metallurgical engineering graduate from the University of Michigan.

Krell Appointed

Frederick K. Krell has been appointed Chicago district sales representative of Globe Steel Tubes Co.

Krell has been with Globe since 1942 serving in the capacity of sales service supervisor.

New Bristol Offices

The Bristol Company has moved its Houston office to 1705 West Gray. E. A. Merwin is district manager.

Link-Belt Names Yetter

Link-Belt Company announces that John Yetter has been appointed district sales engineer, Ball & Roller Bearing Division, with headquarters in Dallas.

Yetter, a 1942 graduate of Texas A&M, joined Link-Belt about two years ago and spent most of a year in training at the company's Ball & Roller Bearing Division plant in Indianapolis.

Leslie Company Conference

A technical and engineering conference for its agents in the Gulf Coast area was held recently in New Orleans, by Leslie Company, Lyndhurst, N. J. Discussed were several new applications for automatic control equipment and a number of new regulators were described and presented.

The conference was conducted by Russell W. Boettiver, sales manager.

Plane is His Office

Robert T. Sheen, president of Milton Roy Company of Philadelphia, with his Republic Seabee christened "The Flying Step Valve," which he has equipped as a flying "office" from which he transacts his business on sales tours throughout the country almost as if he were in his own executive office at 1300 East Mermaid Avenue, Chestnut Hill, Philadelphia. Sheen's office-equipped plane contains such novel installations as a recorder for dictating correspondence while in flight, an electric razor and numerous other devices. The two front seats are also equipped with Irving parachute seats and cushions.

Honeywell-Brown European Subsidiary Managers Meet

Foreign managers of the Brown Instrument Company and its parent organization, Minneapolis-Honeywell Regulator Company, recently held in London their first international connection since the war. Managers and supervisory personnel of its five European subsidiaries laid plans for expanded sales activity according to Harold W. Sweatt, president, who attended along with Thomas McDonald, vice president in charge of sales, and William Westphal, manager of the International Division. Foreign producers, Mr. Sweatt said, are looking to the newer electronic instruments to increase efficiencies and help bring about greater exports with which to get dollar exchange.

Construction Engineers with experience in construction of petroleum refineries and qualified to take responsible charge of large refinery construction projects. State education, qualifications, experience, salary requirements, and date available. Address: Box 8 R, c/o Petroleum Refiner, Houston 1, Texas.

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REFINERY PIPING SUPERINTENDENT wanted for construction work in California. State experience record. Address Box 55-R, c/o Petroleum Refiner, Houston, Texas.

GRADUATE ENGINEER and designer with refinery experience can handle additional exclusive accounts as manufacturer's agent. Successful record and favorable acquaintances among buyers, engineers, architects and contractors in Ohio and Northwestern Pa. Address: Box 16-R, c/o Petroleum Refiner, Houston, Texas.

WANTED—MECHANICAL OR METALLURGICAL ENGINEER—familiar with the inspection of refinery fractionating equipment, furnaces, heat exchangers and pressure vessels and having experience to qualify for making recommendations for renewal or repairs to the equipment. Experience on catalytic cracking units preferred, but not essential. In replying, please send full details of experience and education. Snapshot (if available). Address: Box 10-R, c/o Petroleum Refiner, Houston, Texas.

Construction Engineers with experience in construction of petroleum refineries. State education, qualifications, experience, salary requirements, and date available. Address: Box 9-R, c/o Petroleum Refiner, Houston 1, Texas.

CHIEF ENGINEER Wanted

Chief Engineer for well known established firm of Engineers & Constructors. Prefer man with 15 to 20 years of mechanical and process experience in Petroleum, Refining, Chemical and Power to organize and direct engineering work with complete responsibility. Excellent salary and bonus arrangement. Location—Midwest. Address: Box 15-R, c/o Petroleum Refiner, Houston Texas.

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Liberal salaries—other cash allowances—generous savings and retirement plan—paid vacations in the U. S. plus travel expenses—excellent chances for promotion.

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